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WOW FLUTTER METER

U.S. PIONEER
ELECTRONICS

SER. NO.

V AC OPERATION

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SECTION 1

GENERAL DESCRIPTION

1.1 Introduction

The MK-668C is most suited for accurate measurements of the wow flutter content in tape recorders and other equipment used in reproduction of sound and video signals.

The instrument is provided with circuits for measurements in accordance with the standards presently in use. The 3kHz input signal is used for the NAB, JIS, and CCIR conditions and 3.15kHz input for the DIN (IEC/ANSI) condition. Indications are calibrated in terms of average value for NAB, effective value for JIS, and peak for CCIR and DIN.

The wide range covered in measurements, 0.003% to 10%, is convenient in testing for wow flutter in practically all types of equipment.

In addition the tape speed in terms of frequency can be determined at the same time with the wow flutter characteristics. For this purpose a 4-digit frequency counter is incorporated in the MK-668C. Furthermore, the counter can be used in frequency measurements covering the 10Hz to 40kHz. For the time base reference, the AC line frequency or the internal crystal oscillator can be used. This enables accurate testing of AC line and battery-operated equipment. Other features included are -

- * Measurements possible with input as low as 0.5mVrms.
- * Monitor indication for proper input voltages.
- * Testing under weighted and unweighted conditions.
- * Separate wow and flutter measurements.
- * Accurate recording signal output at 3kHz and 3.15kHz.
- * Easily accessible adjusters for correlation with other wow flutter meters.
- * Output connections provided for observation or recording of waveforms, magnitudes and tape speed drift.

1.2 Specifications

Wow Flutter Measurements

Input Frequencies	3kHz $\pm$ 300Hz, and 3.15kHz $\pm$ 300Hz.
Input Range	Two ranges: 0.5 - 30mVrms, and 5 - 30Vrms.
Input Impedance	300k Ω $\pm$ 30%; unbalanced.
Wow Flutter Range	0.003% - 10% in six ranges: 0.03%, 0.1%, 0.3%, 1%, 3%, and 10% at full scale.
Indication Accuracy	Within $\pm$ 5% of full scale at 4Hz at all ranges.
Indication Mode	JIS: Effective values. NAB: Average values. CCIR-DIN(IEC/ANSI): Peak values.

Frequency Characteristics

Weighted	In accordance with standards of JIS, NAB, and CCIR-DIN.
Wow	0.5 - 6Hz.
Flutter	6 - 200Hz
Unweighted	For JIS and NAB: -3 $\pm$ 1dB 0.5 - 200Hz; roll-off - > 6dB/oct below 0.5Hz > 15dB/oct above 200Hz. For CCIR-DIN: -3 $\pm$ 1dB 0.3 - 200Hz; roll-off: > 6dB/oct below 0.3Hz > 15dB/oct above 200Hz.

Tape Speed Indication 3 $\pm$ 1kHz.

Recording Signal

Frequencies	3kHz and 3.15kHz within $\pm$ 30ppm, crystal-controlled.
Output Voltage	0.2Vrms $\pm$ 20% at open circuit.
Output Impedance	600 Ω $\pm$ 20%; unbalanced.
Distortion	< 1%.

Output Voltage	$\pm 1.0\text{V} \pm 20\%$ per 1% drift.
Output Impedance	$10\text{k}\Omega \pm 20\%$; unbalanced.

Wow Flutter Output Signal - DC

Output Voltage	0.3V $\pm 20\%$ at full scale
Output Impedance	10k Ω $\pm 20\%$; floated above ground.

Wow Flutter Output Signal - AC

Output Voltage	3V _{rms} ±20% at full scale.
Output Impedance	10kΩ ±20%; unbalanced.

Frequency Measurements

Range	10 - 9,999Hz, direct reading; to 40kHz with addition of first significant digit.
Input Voltage	100mV - 30Vrms.
Input Impedance	300k Ω $\pm$ 20%; unbalanced.
Display	4-digit type.
Gate Time	1 second.
Accuracy	$\pm$ (1 count + reference frequency accuracy).
Reference Frequencies	Internal: 2.52MHz within $\pm$ 30ppm.

Warm-up Time	Approximately three minutes.
Operating Temperature Range	0 - 40°C.
Power Requirements	100/120/200/240V, 50/60Hz; approx. 18VA.
Dimensions	Approx. 350(W)x150(H)x280(D) mm.
Weight	Approx. 5kg.

Accessories, furnished -

Cord for input and output connections, MC-2204	2 ea.
Fuse: 1A for 100/120V, or 0.5A for 200/240V	2 ea.
Pilot lamp, 12V-20mA	1 ea.
Instruction Manual	1 ea.

1.3 Controls and Terminals

1.3.1 Front Panel, Fig. 1-1

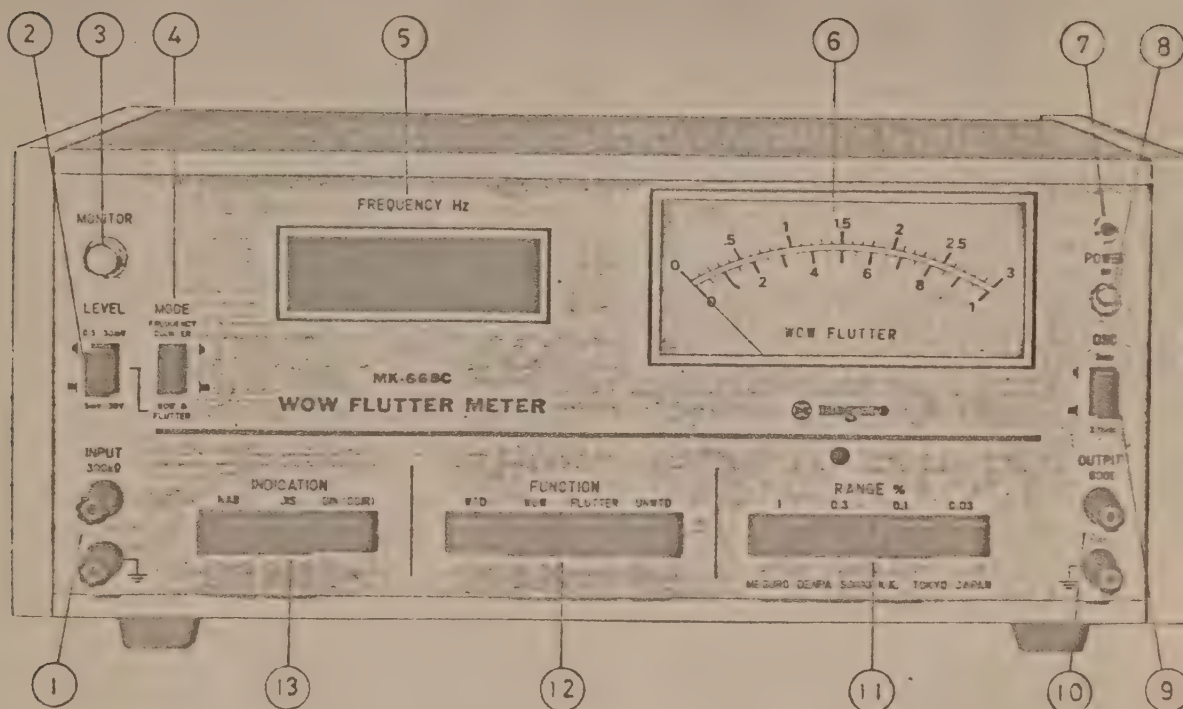


Fig. 1-1 Front panel controls.

- 1 INPUT terminals: For connection to the test circuit for measurements of wow flutter and frequency.
- 2 LEVEL switch: To be set as indicated depending on the wow flutter input voltage range.
- 3 MONITOR lamp: Indicates at proper input voltage levels for wow flutter measurements as set with the LEVEL switch, or over 100mV for frequency measurements.
- 4 MODE switch: For wow flutter + tape speed measurements at "out" and frequency only at "in".
- 5 FREQUENCY Hz: 4-digit display for the wow flutter input and tape speed, and for frequency measurements.
- 6 WOW FLUTTER meter: With two scales, 0-1% and 0-3%; actual range depends on the RANGE switch, 11, setting.
- 7 Pilot lamp: Indicates when the AC power is on.
- 8 POWER switch: For turning on the AC power for operation.



- 9 OSCillator selector: With two settings, 3kHz and 3.15kHz, for the recording signal frequencies.
- 10 OUTPUT terminals: For the recording signal outputs.
- 11 RANGE switches: For selection of full scale ranges of the WOW FLUTTER meter; with use of the SELECTOR switch, 25, at right side of the case, the ranges can be increased by a factor of 10.
 - WTD (Weighted)) In accordance with the JIS, NAB, UNWTD (Unweighted) and CCIR-DIN specifications.
 - WOW For the wow in the 0.5 - 6kHz range.
 - FLUTTER For the flutter in the 6 - 200Hz range.
- 13 INDICATION switches: For wow flutter values in accordance with NAB (average), JIS (effective) and DIN or CCIR (peak).

1.3.2 Rear Panel, Fig. 1-2

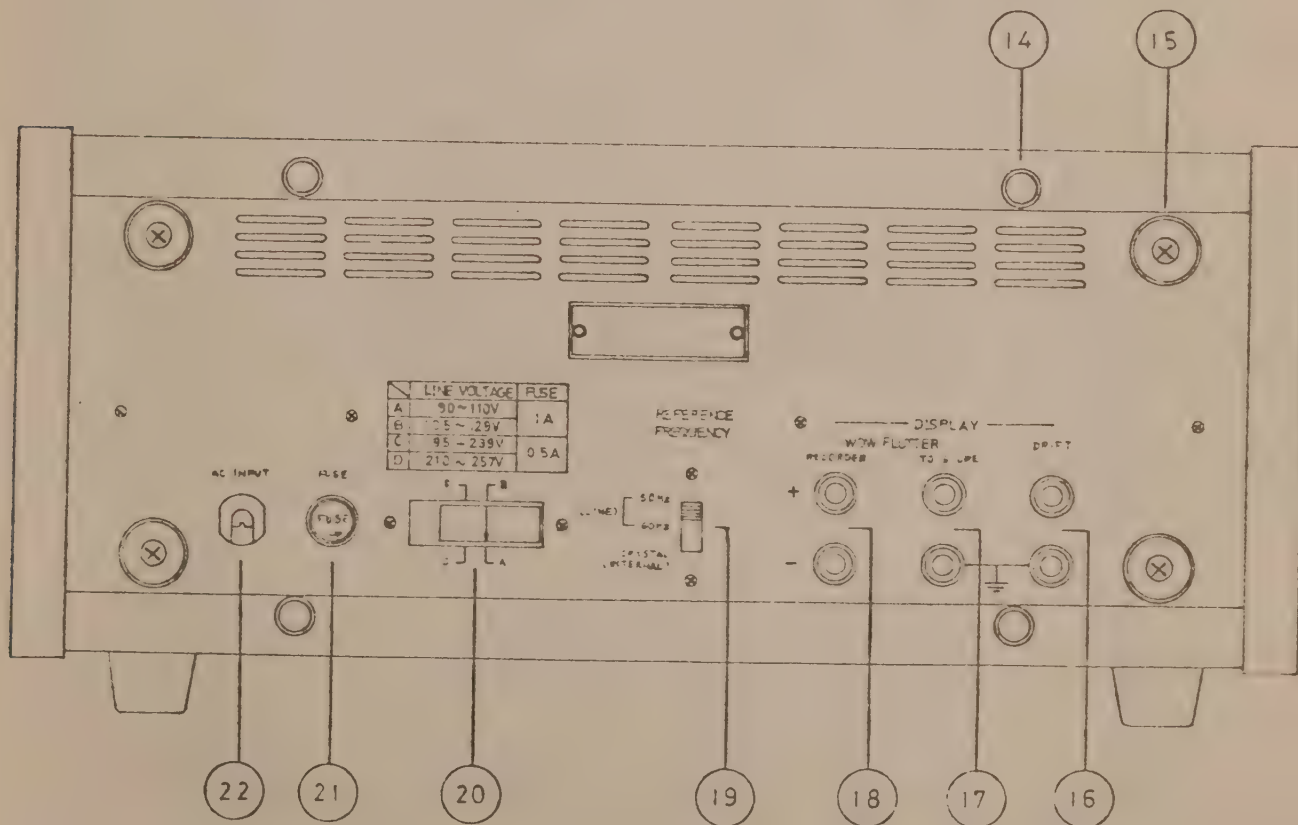


Fig. 1-2 Rear panel controls.

- 14 Cover lock (captive type) – two each for top and bottom covers; to be pulled when removing covers for inspection.
- 15 Hook (4 ea.) for AC cord storage.
- 16 DRIFT signal output terminals.
- 17 TO SCOPE terminals: For connection to an oscilloscope for waveform observation or frequency analysis of wow flutter signals.
- 18 RECORDER terminals: DC output is available, proportional to the wow flutter indication, for permanent recording.
- 19 REFERENCE FREQUENCY switch: Selects the time base frequency used in the counter.
- 20 VOLTAGE SELECTOR plug: To be inserted in the socket so that the arrow marking is at the proper letter for the AC line voltage range.
- 21 FUSEholder: For the AC line fuse; the rating is shown in the table.
- 22 AC INPUT: AC cord.

1.3.3 Left Side of Case, Fig. 1-3

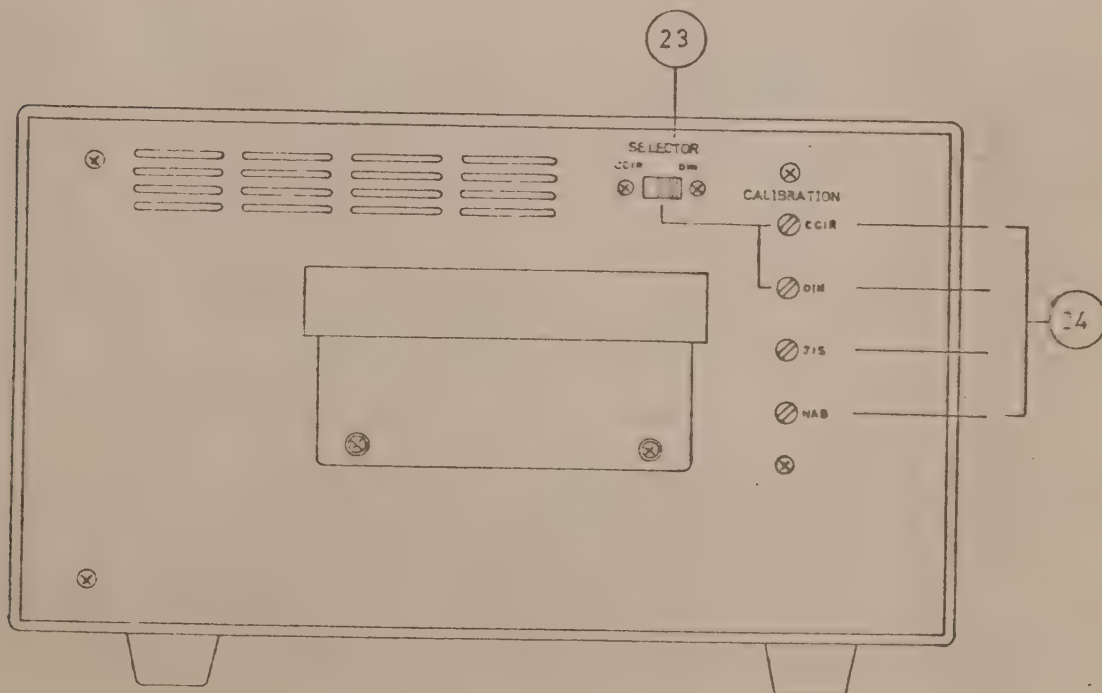


Fig. 1-3 Left side of case.

- 23 **SELECTOR switch:** For setting at CCIR or at DIN when the DIN(CCIR) switch of INDICATION, 13, is in use.
- 24 **CALIBRATION adjusters:** Used in calibration of the respective metering circuits.

1.3.4 Right Side of Case, Fig. 1-4

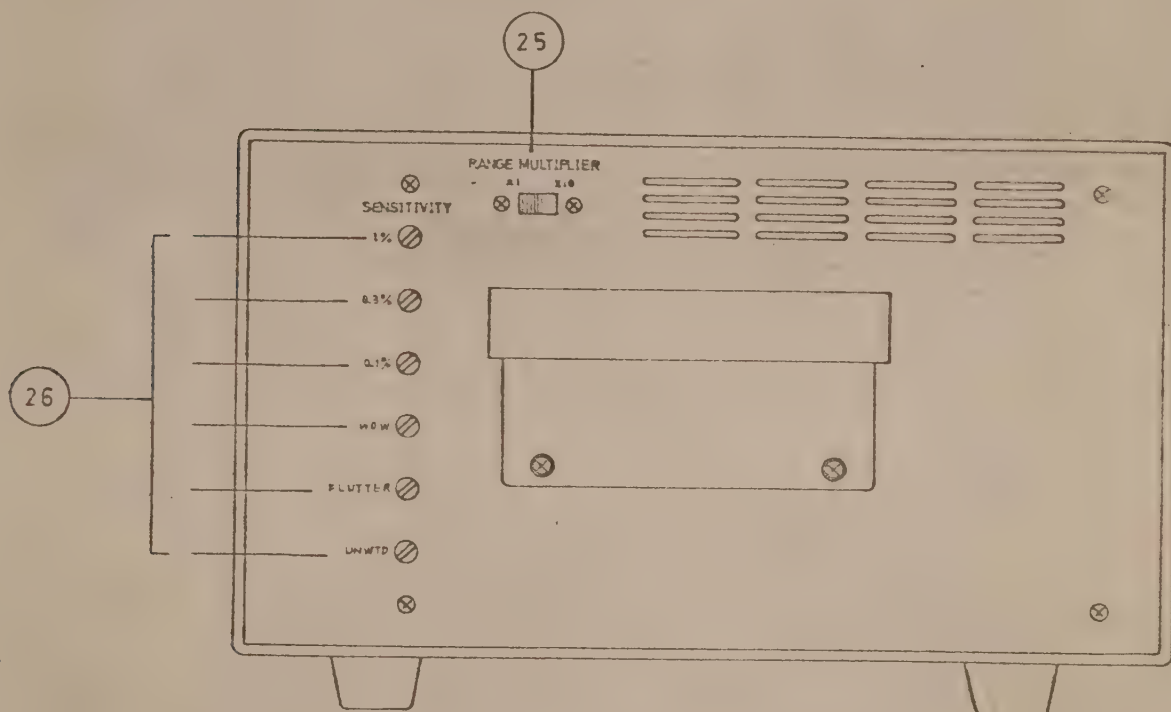


Fig. 1-4 Right side of case.

- 25 **RANGE MULTIPLIER switch:** For increasing the wow flutter measuring ranges, at the four settings, by a factor of 10; normally set at X1.
- 26 **SENSITIVITY adjusters:**
- 1%, 0.3%, and 0.1% - for the RANGE switches;
 - WOW, FLUTTER, and UNWTD - for equalizing the frequency response networks.

SECTION 2

OPERATION

2.1 Precautions in Use

- A. Before setting the POWER switch at ON, check the inserted condition of the plug in the VOLTAGE SELECTOR socket.

The AC input voltage should be within the limits marked in the accompanying table.

- B. The maximum DC voltage, if superposed on the test signal, should not exceed 100V; this is to protect the input circuit.

2.2 Wow Flutter Measurements

1. Initial settings:

At front panel -

POWER switch at off.

FUNCTION switch at WTD (Weighted) or UNWTD (Unweighted) depending on measuring conditions.

INDICATION switch at NAB, JIS or DIN(CCIR).

NOTE: If the DIN(CCIR) is used, check the SELECTOR switch setting, at left side of the case, DIN or CCIR.

RANGE switch at 1%.

LEVEL switch at 5mV-30V.

MODE switch at WOW & FLUTTER.

Other switches -

At right side of case: RANGE MULTIPLIER at X1.

At left side of case: SELECTOR at DIN or CCIR when using the DIN(CCIR) of INDICATION (front panel).

At rear of case: REFERENCE FREQUENCY at CRYSTAL, also refer to Sect. 2.4.

2. Connect the AC cord to the AC line.
Set the POWER switch at ON. Allow a few minutes for warm-up.
3. Connect the wow flutter signal from the test circuit to the INPUT terminals.

NOTE: If a standard pre-recorded tape at 3kHz or 3.15kHz is not available, a test tape may be recorded with the signal from the OUTPUT 600Ω terminals, also see Sect. 2.6.

4. MONITOR indication- The lamp will indicate when the input voltage is in the 5mV to 30Vrms range. If the input is lower than 5mV, depress the LEVEL switch to the 5mV-30mV position.

Normally, this switch is set at the 5mV-30V position.

NOTE: The lamp may indicate when the signal is connected but unless the input is within $\pm 300\text{Hz}$ of 3kHz or 3.15kHz, proper wow flutter values cannot be measured.

5. DIN or CCIR measuring conditions -

As mentioned above, when the DIN(CCIR) switch of INDICATION is used, the SELECTOR switch, at left side of case, must be set as follows:

DIN for 3.15kHz input, and

CCIR for 3kHz input.

The WOW FLUTTER meter reading will be in peak values and the sign, $\pm$, must be used in the results.

6. Depress the RANGE % switches as required from 1% to the lower ranges.

If the wow flutter is greater than 1%, set the RANGE MULTIPLIER switch, at right side of case, to X10, and multiply the meter readings by 10 for 10% at full scale; see table given below.

Normally, this switch is set at X1 for direct readouts.

WOW FLUTTER MEASURING RANGES

RANGE setting	RANGE MULTIPLIER setting	
	X1	X10
0.03%	0.003 - 0.03%	0.03 - 0.3%
0.1%	0.01 - 0.1%	0.10 - 1.0%
0.3%	0.03 - 0.3%	0.3 - 3%
1%	0.10 - 1.0%	1.0 - 10%

NOTE: After use of the RANGE MULTIPLIER setting at X10, reset the switch to X1; this will prevent errors in readouts in subsequent operation.

7. For separate measurements of wow and flutter, depress the relevant FUNCTION switch. Indications of the values will depend on the setting of the INDICATION switches.



2.3 Use of the Frequency Counter

A. Tape Speed

At the WOW FLUTTER setting of the MODE switch, measurements are possible at center frequencies of 3kHz and 3.15kHz within ± 1 kHz regardless of settings of FUNCTION, INDICATION, and RANGE switches.

NOTE: Wow flutter measurements, however, can be made only when the input frequencies are within ± 300 Hz of the respective center frequencies.

B. Low Frequencies , 10Hz to 40,000Hz

1. Connections: Test frequency to INPUT terminals.

2. Switch settings:

MODE at FREQUENCY COUNTER.

REFERENCE FREQUENCY (rear panel) at CRYSTAL.

3. The input voltage must be in the 100mV-30Vrms range.

4. Above 9,999Hz, only the last four digits will be displayed, for example, 0500, when the frequency is 10,500, 20,500, etc. Consequently, the approximate input frequency must be known prior to measurements.

2.4 REFERENCE FREQUENCY Switch Settings

Depending on measuring requirements, this switch is generally set at LINE, 50Hz or 60Hz, when testing AC line operated sets. For frequency measurements and tests of battery-operated recorders, etc., the CRYSTAL setting is used.

2.5 Output Signal Connections

Three outputs are provided at DISPLAY connection on the rear panel.

RECORDER output: DC at 0.3V $\pm 20\%$ at full scale meter reading plotting, etc. ; note that the terminals are above ground, i.e. in floating condition.

TO SCOPE output: For waveform observation on an oscilloscope.

DRIFT output: For recording the tape speed drift, or variation.

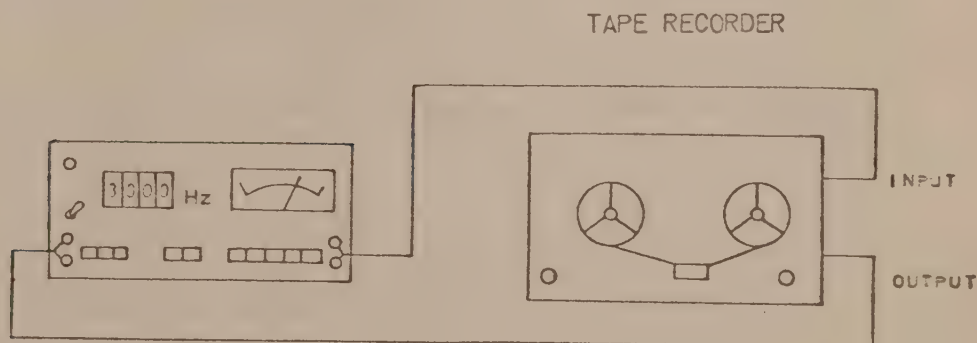
2.6 Test Recording Signal Output

A "standard" test signal at 3kHz or 3.15kHz, accurate to within $\pm 30\text{ppm}$, is available at the OUTPUT 600 Ω terminals (front panel). The output is 0.2Vrms within $\pm 20\%$ at open circuit.

The signal can be recorded on tape for test purposes. Needless to mention, the recording tape deck must be of highest grade, i.e., with very low wow flutter characteristics and with high S/N.

The output signal is available whenever the POWER switch is on.

It is possible to test a tape recorder provided with separate heads for recording and playback by connecting the oscillator output to the input and the output of the recorder to the MK-668C input. The setup is shown in the figure below. Using this method, the overall wow flutter characteristic can be readily determined.



SECTION 3

CIRCUIT DESCRIPTION

3.1 General

Information is given in this section for the circuits used in the MK-668C. The simplified block diagram is shown in Fig. 3-1.

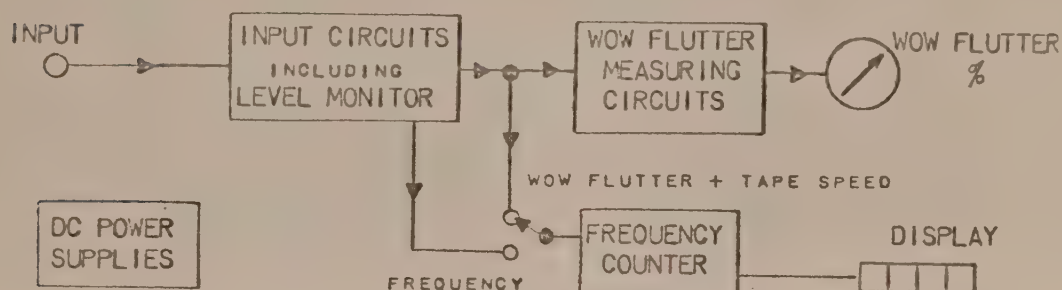


Fig. 3-1 Simplified block diagram: MK-668C.

As indicated, the instrument is composed with the input section, wow flutter measuring circuits, frequency counter, and power supplies.

3.2 Input Section

Reference: SCHEMATIC

1

The sectional block diagram is shown in Fig. 3-2.

The input signal for wow flutter and tape speed measurements is fed to an impedance converter. For protection against over-voltages, two diodes for limiting are included at the input.

The signal from the low impedance output is fed to a bandpass filter to cut off frequencies (noise, etc.) outside the passband. The bandpass characteristic is $\pm 1\text{kHz}$ referred to the center frequency at 3kHz .

A low level amplifier is used to increase the voltage in the 0.5 to 30mV_{rms} input range. The signal is then fed to the limiter-amplifier circuit consisting of two ICs (integrated circuits) to produce the amplitude-limited output for driving the trigger which follows.

The trigger output pulses are fed to a frequency discriminator of the monostable multivibrator type. This circuit is designed for operation with signals within the $\pm 300\text{Hz}$ band of 3kHz or 3.15kHz .

respectively for NAB, JIS, CCIR, or at DIN. To linearize the output signal within the bands, a sliding DC level circuit at the discriminator output.

For the tape speed measurement, a part of the trigger output is fed to the gate circuit in the counter section.

For frequency measurements only (MODE switch at FREQUENCY COUNTER), the signal is derived from the input FET and attenuated to the proper level to be fed to the limiter and trigger and on to the counter gate circuit. At this operating mode, the discriminator output is cut off.

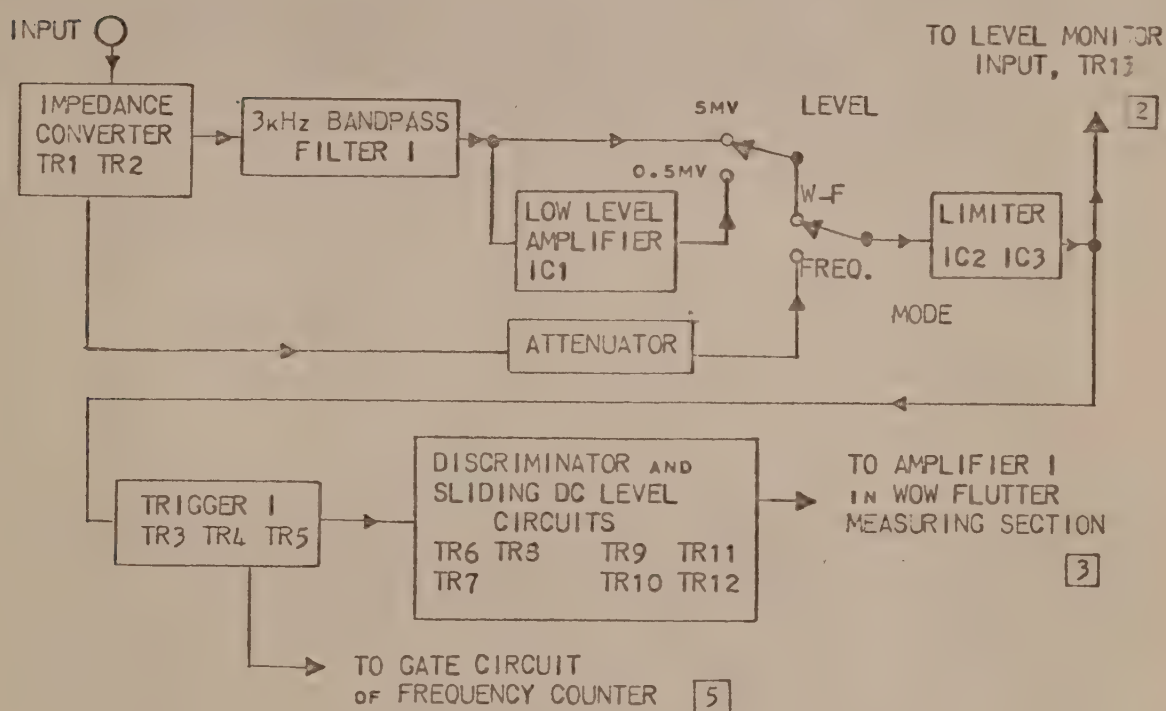


Fig. 3-2 Block diagram: Input section.

3.3 Input Level Monitor

Reference: SCHEMATIC 2

This circuit is used to indicate the output of the limiter-amplifier. In operation, the monitor lamp will light when the wow flutter test input voltage is at or above the lower limits of **LEVEL** switch markings, or above 100mVrms at frequency measurements. At lower than required voltages, the lamp will not light and trigger is biased to cutoff.

The block diagram is shown in Fig. 3-3.

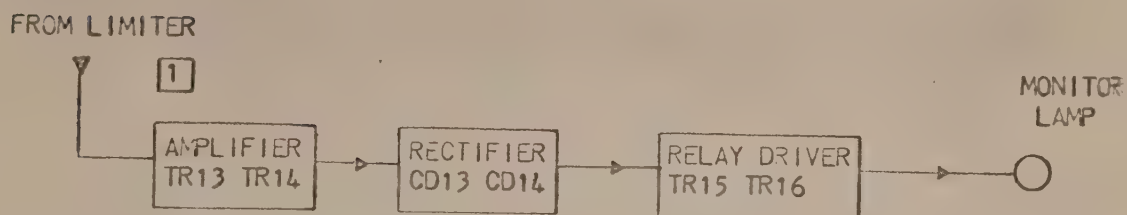


Fig. 3-3 Block diagram: Input level monitor circuit.

3.4 Wow Flutter Measuring Section

Reference: SCHEMATIC [3]

The block diagram of this section is shown in Fig. 3-4.

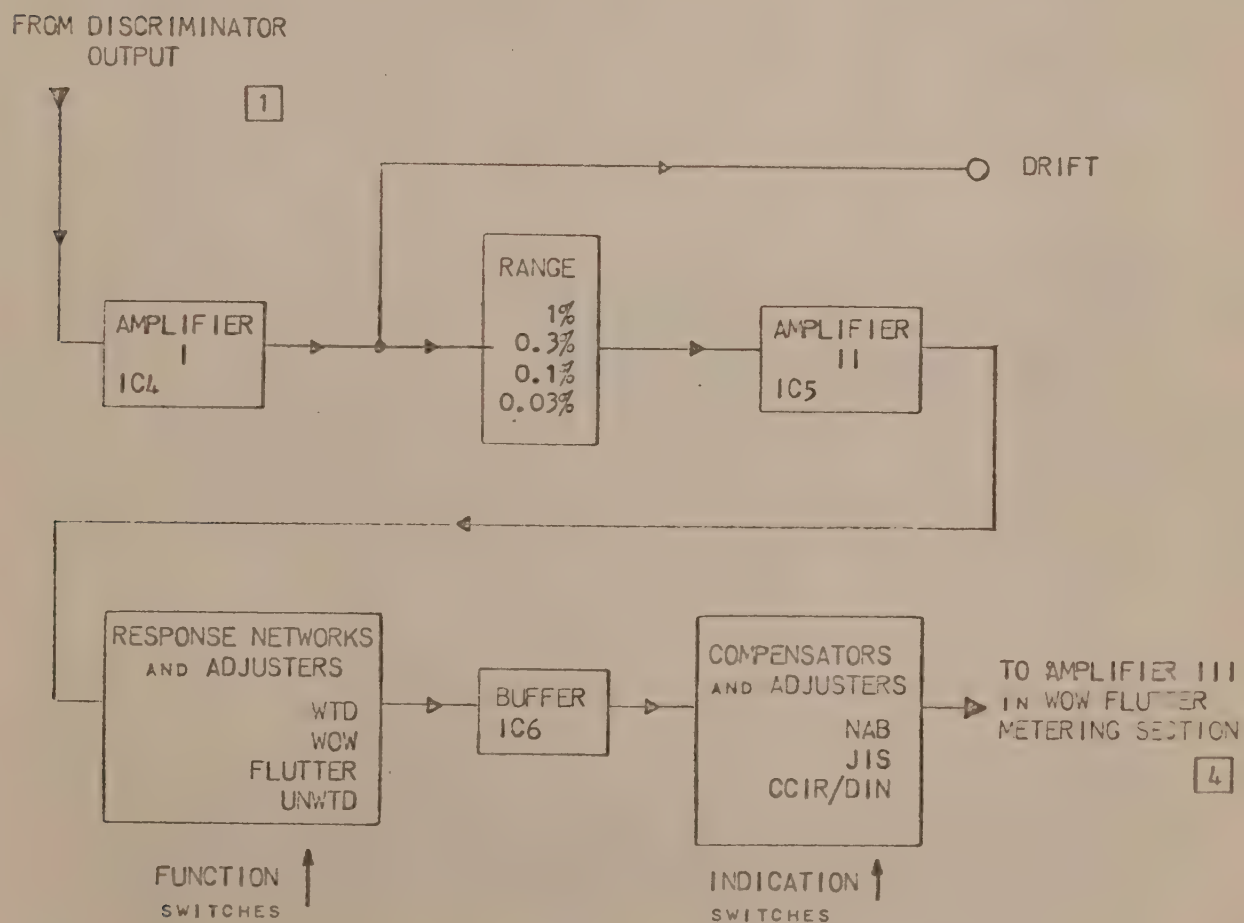


Fig. 3-4 Block diagram: Wow flutter measuring section.

The signal from the discriminator circuit (sect. 3.2) is fed to a lowpass filter, with cutoff at approximately 300Hz, to eliminate the 3kHz and 3.15kHz carrier and on to AMPLIFIER I (IC4). The output is then fed to the range attenuators, 1.0%, etc., and to another lowpass filter and AMPLIFIER II. This second filter is used to further the elimination of the carrier component to insure accuracy in measurements.

The wow flutter signal is then applied through the FUNCTION switches to the weighted (WTD), WOW, FLUTTER, and unweighted (UNWTD) frequency networks. Three level adjusters are provided to equalize output signals from the latter three networks.

The buffer, IC6, is used to isolate the networks from the frequency compensating capacitors and level adjusters for measurements under NAB, JIS, and CCIR/DIN conditions

The drift output signal (tape speed) is taken off at the output of AMPLIFIER I.

3.5 Metering Circuits

Reference: SCHEMATIC 4

The block diagram of the wow flutter metering circuit is shown in Fig. 3-5.

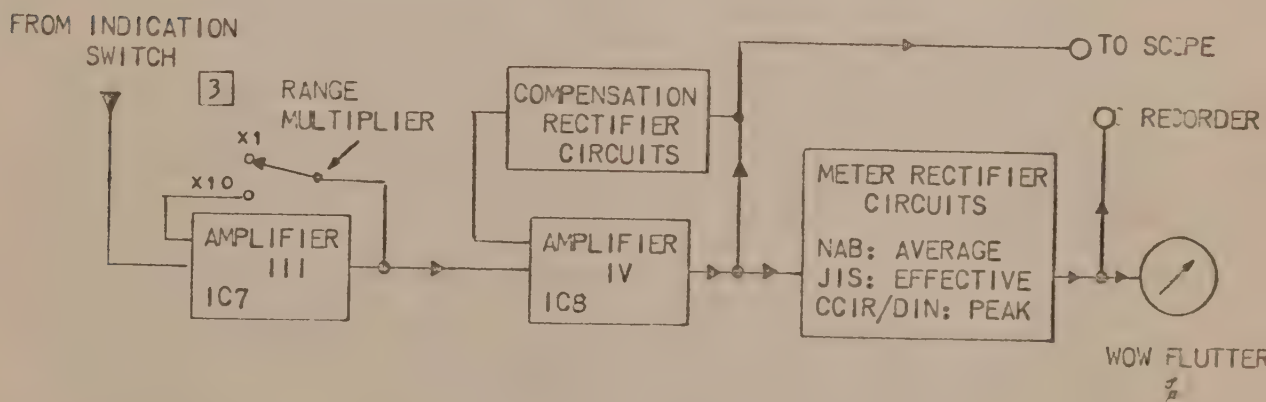


Fig. 3-5 Block diagram: Wow flutter metering circuits.

The wow flutter signal selected with the INDICATION switches, is fed to AMPLIFIER III where the range multiplication, X1 or X10 ("shorted"), is applied. After further amplification with AMPLIFIER IV, the selected signal is switched to respective meter rectifier circuits. Rectifier output circuits depend on the measuring standards and are arranged as follows:

NAB: For indication of average value at sine wave input.



JIS: For indication of effective (quasi-effective) value of the input, or 2(peak/effective); an R-C network is used for this purpose.

CCIR/DIN: For indication of the peak value of the input; suitable capacitors are used in circuit to obtain the proper charge-discharge time constant.

It will be noted that a rectifier circuit is included in the feedback of AMPLIFIER IV. This circuit is used for two purposes, 1) for compensation for temperature effect and 2) for linearity in the output of meter rectifiers as used in the three different measuring conditions.

Connections to an external oscilloscope, recorder, etc., for observation or recording waveforms and magnitudes of wow flutter signals for analysis are provided at the outputs of AMPLIFIER IV and across the meter respectively.

3.6 Frequency Counter Circuits

A. Time Base and Input Circuits

Reference: SCHEMATIC 5

The block diagram is shown in Fig. 3-6.

Initially the reference frequencies at 50 or 60Hz of the AC line and the 2.52MHz internal crystal oscillator respectively are stepped down by factors of 1/5, 1/6, and 1/252,000 with respective frequency dividers to produce the 10Hz timing pulses.

After selection with the REFERENCE FREQUENCY switch, the 1-second time base signal is generated with the 10:1 divider, IC15. For gating the input frequency signal, a 0.5 second pulse is generated with a 2:1 divider, IC16.

The memory pulse is generated with the monostable multivibrator, IC19b-c and IC18a circuit. This pulse is applied to the 4-digit counter at the time the gate is closed (end of counting operation and during which time the contents are memorized).

At the end of the memorizing, the reset pulser is used to reset the 4-digit counter for the succeeding count operation.

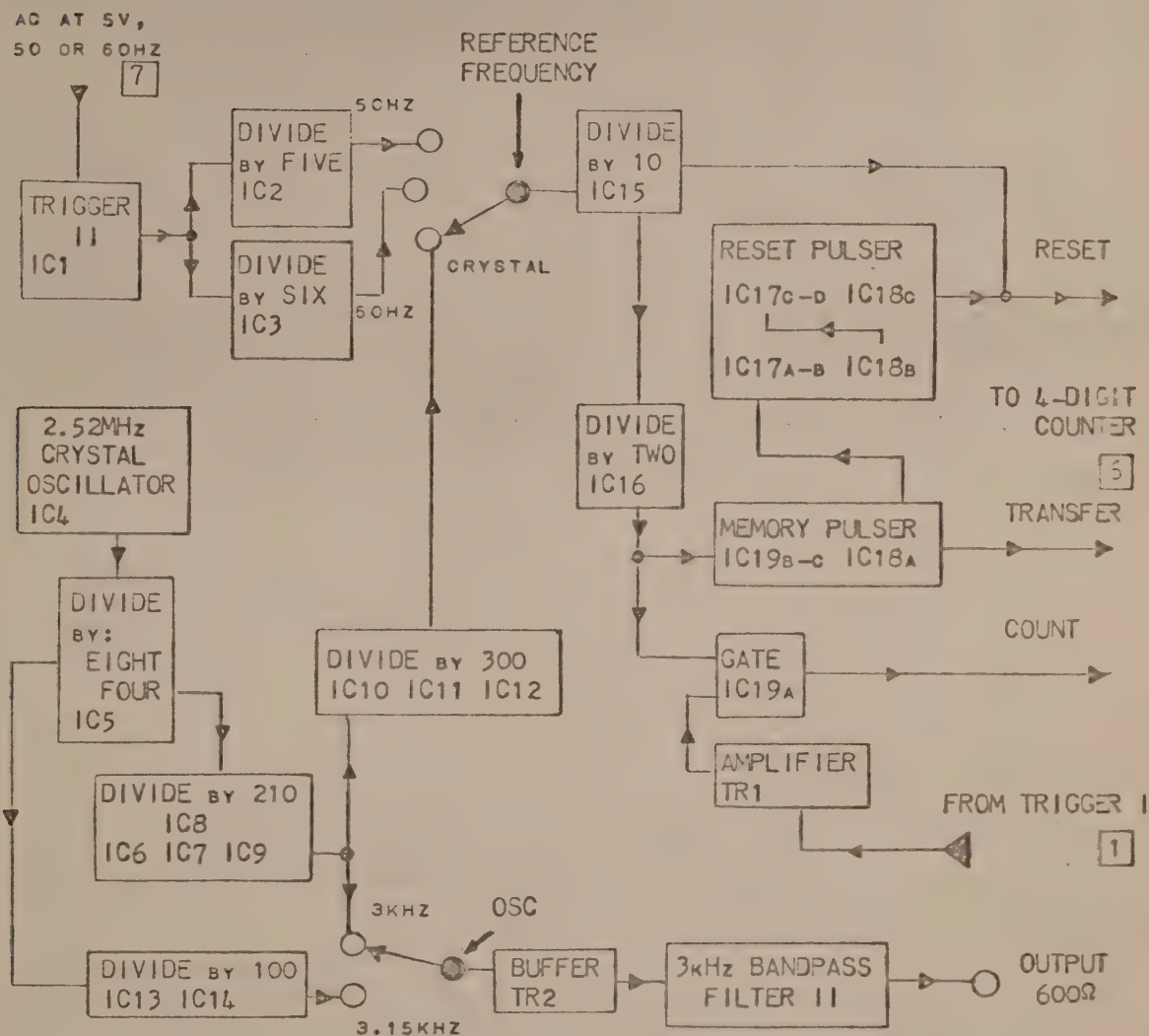


Fig. 3-6 Block diagram: Counter time base and input circuits.

B. 4-digit Counter and Frequency Display

Reference: SCHEMATIC 6

The control pulses, memory, transfer, and reset, from the time base section are applied to the 4-digit counter unit, IC1. This unit is composed with four decade counter and latch circuits, a multiplexer, T-counter and a scanning oscillator.

The BCD output at each decade is decoded in decimal form for the numeric indication, 0 -- 9, in the display tubes.

Transistors, Q1 -- Q8, in the +200V supply line are used as switches in driving the display tubes.

The block diagram for the counter unit and display section is shown in Fig. 3-7.

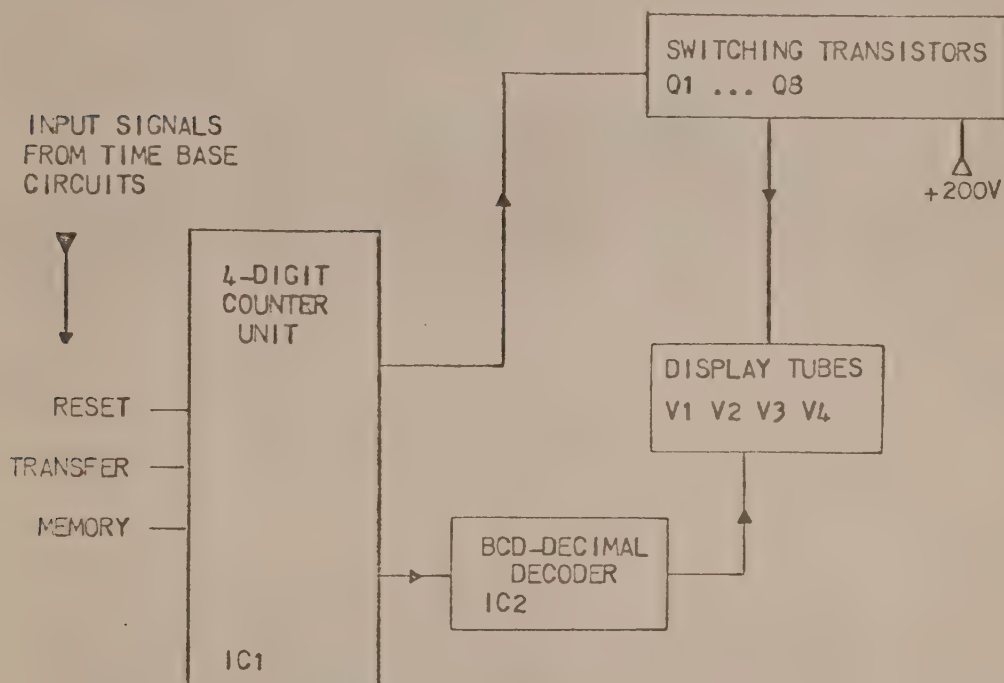


Fig. 3-7 Block diagram: Counter unit and display section.

3.7 Recording Signal Output

Reference: SCHEMATIC [5], and Fig. 3-6

The 2.52MHz crystal oscillator output is used in generation of accurate 3kHz and 3.15kHz signals. The respective frequencies are obtained as follows:

3kHz After frequency division, 840:1 ($=1/4 \times 1/210$)

3.15kHz After frequency division, 800:1 ($=1/8 \times 1/100$)

The selected frequency is fed to an emitter follower, TR2, and a 3kHz bandpass filter to the output terminals.

3.8 Power Supplies

Reference: SCHEMATIC

7

Four DC voltages are used in the operation as given in the table below.

AC INPUT from T101	RECTIFIER	REGULATOR	DC OUTPUT VOLTAGE
20-0-20V	CD4	TR101 TR3, TR4 IC20 CD5, CD6	+15V
	CD4	TR102 TR5, TR6 IC21 CD7, CD8	-15V
10V	IC1		+5V
100V	CD2, CD3	--	+200V

The AC input to TRIGGER II (SCHEMATIC 5) is derived through a 130k Ω resistor in the 100V supply (terminal 13).

The Power Transformer, T101, input is tapped for use at four different input voltages and the selection is made with plug connections.

The line filter, FIL101, is effective in eliminating noise in the 0.15 - 15MHz range.



SECTION 4

PERFORMANCE CHECKS AND MAINTENANCE

4.1 General

- A. Routine checks, at least once every six months, should be made on the instrument to insure proper operating performance. Only qualified personnel should undertake the work.
- B. Before checking, allow sufficient time for warm-up in the MK-668C and test equipment.
- C. When any of the parts require replacement, use only those specified in the parts list, or equivalents.
- D. After a part has been replaced, the relevant circuit must be checked and/or recalibrated.

NOTES ON CIRCUIT ADJUSTMENTS

1. Before turning on the AC power, check the zero setting at the left end of of meter scales; if the pointer is not properly set, adjust the mechanical zero-adjusting screw at front center of the meter.
2. Reference to the schematics should be made when checking the circuit parts.

4.2 Test Equipment Required

Name	Data	Use	Remarks *
Wow flutter calibrator	For 3kHz signal: range, 0-3%	Response, indication, calibration	MWS-670A MWS-671
	Above with pulse output		MWS-670B MWS-670C
Frequency counter	0.1Hz-1MHz	Measurement of tape speed and flutter rate	
Oscilloscope	DC-1MHz	Waveform and amplitude	
AC millivolt-meter	1mV-100Vrms	Voltage checks	MV-12A
DC voltmeter	0-30V	Voltage checks	
Low frequency oscillator	5Hz-1MHz	Tape speed calibration	MCR-403
Attenuator box	0-60dB, in 0.1dB steps; 600Ω	Input voltage adjustment	

* Recommended MEGURO DENPA instruments

4.3 Exposing the Chassis

For inspection and checking, top and bottom covers can be removed by pulling out the two captive buttons on each cover at the back.

NOTE: Disconnect the AC cord plug from the AC line when removing the covers.

4.4 Test Points and Internal Adjusters

TOP VIEWS Fig. 4-7 Page 34 (PCB-2)

BOTTOM VIEWS Fig. 4-8 Page 35 (PCB-1)

4.5 Preparation

1. Switch settings:

a. Front panel -

POWER at off.

FUNCTION WTD, or UNWTD.

INDICATION JIS.

RANGE 1%.

LEVEL 5mV-30V.

MODE FREQUENCY COUNTER.

b. Others -

Rear panel: REFERENCE FREQUENCY CRYSTAL.

Left side: SELECTOR CCIR.

Right side: RANGE MULTIPLIER X1.

2. Connect the AC plug to the AC line and set the POWER switch at ON. Allow at least five minutes for warm-up.

4.6 Wow Flutter Range Checking

Specification: Accuracy within $\pm 5\%$ of full scale at each range.

Connections: See Fig. 4-1.

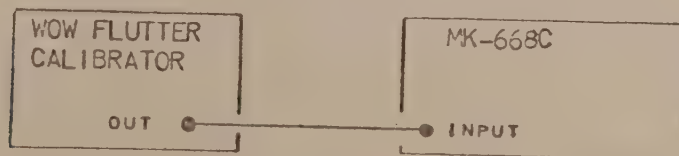


Fig. 4-1 Wow flutter range checking.



1. Initial settings:

WOW FLUTTER CALIBRATOR		MK-668C	
WOW FREQUENCY	4Hz	MODE	W-F
WAVEFORM	SINE	INDICATION	JIS
INDICATION	JIS	FUNCTION	WTD
OUTPUT LEVEL	Above 100mV		

2. Check and adjustments

Range Settings : CALIBRATOR and MK-668C	Adjust, if required, for full scale meter reading	Adjuster Location
0.03% *	"JIS"	Left side
0.1%	"0.1%"	Right side
0.3%	"0.3%"	
1%	"1%"	

* This range is the reference for other ranges.

4.7 FUNCTION Characteristic

Specification: Accuracy within $\pm 5\%$ of full scale at each function.

Connections: See Fig. 4-1.

1. Initial settings:

WOW FLUTTER CALIBRATOR		MK-668C	
CENTER FREQUENCY	3kHz	MODE	W-F
WAVEFORM	SINE	INDICATION	JIS
WOW FLUTTER	1%	RANGE	1%
WOW FREQUENCY	4Hz	FUNCTION	WTD
INDICATION	JIS		
OUTPUT LEVEL	Above 100mV		

2. Check and adjustments

CALIBRATOR Setting	MK-668C Setting	Adjust, if required, for full scale meter reading
WOW FREQUENCY:	FUNCTION:	
4Hz*	WTD	"JIS" (left side)
1Hz	WOW	"WOW"
30Hz	FLUTTER	"FLUTTER" (right side)
	UNWTD	"UNWTD"

* This frequency is the reference for other frequencies.

4.8 INDICATION Checking

Specification: Accuracy within $\pm 5\%$ of full scale.

Connections: See Fig. 4-1.

1. Initial settings:

WOW FLUTTER CALIBRATOR		MK-668C	
CENTER FREQUENCY	3kHz	MODE	W-F
WOW FLUTTER	1%	INDICATION	JIS
WOW FREQUENCY	30Hz	FUNCTION	UNWTD
WAVEFORM	SINE	SELECTOR	CCIR (left side)
INDICATION	JIS		
OUTPUT LEVEL	Above 100mV		

2. Check and adjustments

CALIBRATOR Setting	MK-668C Setting	Adjust, if required, for full scale meter reading
INDICATION:		
JIS	JIS	"JIS"
NAB	NAB	"NAB" (left side)
CCIR	CCIR	"CCIR"
DIN (at 3.15kHz) (see note)	DIN	"DIN" w/SELECTOR at DIN

NOTE: Model MWS-670C Calibrator is provided with output at 3.15kHz.
When Model MWS-670B Calibrator is used for DIN in above test, the "DIN" adjuster in MK-668C must be set for 95% full scale reading.

4.9 DIN (CCIR) Indication Characteristics

1. Connections: See Fig. 4-1. The wow flutter calibrator, MWS-670B or MWS-670C, is connected to the INPUT of MK-668C.

NOTE: The MWS-670A is not provided for the following test.

2. Initial settings:

CALIBRATOR		MK-668C	
CENTER FREQUENCY	3kHz	FUNCTION	WTD
FUNCTION	CCIR PULSE	INDICATION	DIN(CCIR)
PULSE DURATION	100ms	RANGE %	1%
OUTPUT LEVEL	Above 100mV	SELECTOR (left side)	CCIR

3. Check and adjustments

The meter should indicate between $1.00\% \pm 0.04\%$ at maximum and $0.4\% \pm 0.1\%$ at minimum. If not, then adjust R100, see Fig. 4-8.

Recheck by setting the Calibrator at CCIR, 4Hz and 1%; the reading should be at full scale.

Next set the Calibrator pulse duration at 100, 60, 30 and 10ms respectively. At each step, the meter indication should be in the range as follows:

100ms	0.96 - 1.04
60ms	0.84 - 0.96
30ms	0.56 - 0.68
10ms	0.18 - 0.24

If the indications are outside the given ranges, adjust R99, see Fig. 4-8. Recheck with procedures given above, particularly at the 1% full scale condition; readjust R99 if necessary.

4.10 INPUT LEVEL MONITOR Checking

Specification: Indication at 0.5–30mV and 5mV–30V input ranges.

Connections: See Fig. 4-2.

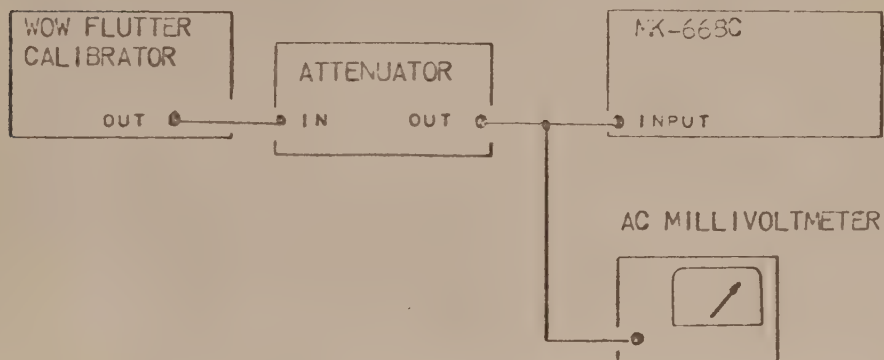


Fig. 4-2 Input LEVEL MONITOR checking.

At the 5mV–30V range, the lamp should light when the input is at 5mV. If not, adjust R54 on PCB-1, see Fig. 4-8, page 35.

Check the lighting condition with the switch at the 0.5–30mV range and input voltage at 0.5mV.

4.11 Oscillator Output Voltage

Specification: At 3kHz and 3.15kHz, the output should be 0.2Vrms $\pm 20\%$ at open circuit.

Connections: See Fig. 4-3.

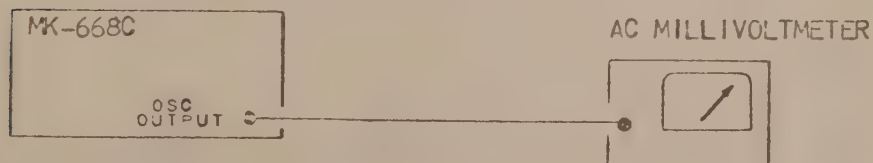


Fig. 4-3 Oscillator output checking.

If the output is not within $\pm 20\%$ of 0.2Vrms, adjust R15; see Fig. 4-7, page 34.

4.12 Rear Panel Outputs

A. DRIFT

Specification: At $\pm 1\%$ drift, output at $\pm 1V$ within $\pm 20\%$.

Connections : See Fig. 4-4.

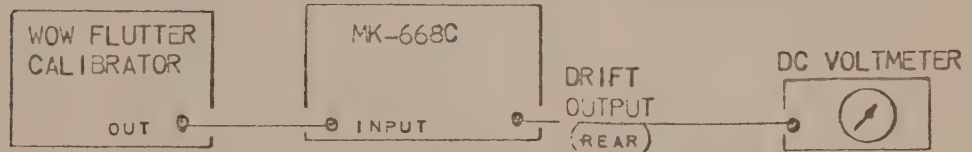


Fig. 4-4 Drift output signal checking.

Procedure:

1. Set the Calibrator frequency at 3,000Hz.
2. The output voltage should be 0VDC. If not, adjust R36, see Fig. 4-8, page 35.
3. Set the Calibrator frequency at 2,970Hz and 3,030Hz. The output should be -1V and +1V within $\pm 20\%$ at each frequency respectively.
4. Next, set the Calibrator frequency at 3,150Hz. If not, adjust R39.

Set the Calibrator frequency at 3,128.5Hz and 3,181.5Hz. The output at each frequency should be -1V and +1V within $\pm 20\%$ respectively.

B. TO SCOPE, and TO RECORDER

Connections: See Fig. 4-5.

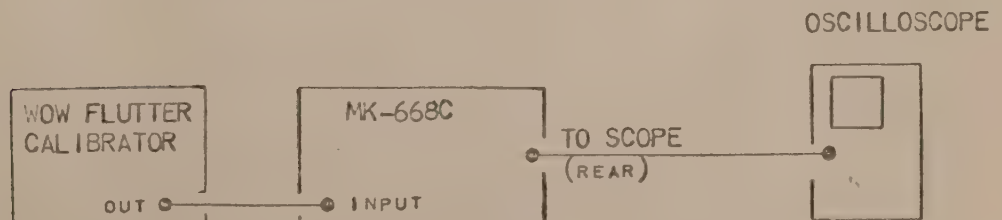


Fig. 4-5 Output checking at TO SCOPE
and TO RECORDER terminals.

1. Initial settings:

CALIBRATOR		MK-668C	
CENTER FREQUENCY	3kHz	MODE	W & F
WOW FREQUENCY	4Hz	INDICATION	JIS
WAVEFORM	SINE	FUNCTION	WTD
INDICATION	JIS	RANGE %	1%
WOW FLUTTER	1%		

2. Checking:

At TO SCOPE terminals: Output amplitude should be 3Vrms, or within limits from 7.3 to 10.1Vp-p.

At TO RECORDER terminals: Output voltage, measured with a DC voltmeter, or DC oscilloscope, should be within the limits from 0.24 to 0.36V.

NOTE: No adjusters are provided for the outputs.

4.13 DC Balance in DC Amplifiers

NOTES: a. Checks are made with the POWER switch at ON but with no input signal.

b. Refer to Fig. 4-8 for test points and adjusters.

Connect a low range DC voltmeter, preferably with 0 center, at the test points.

At each test point the voltage should be 0V. If not, the DC balance is made with the relevant adjusters as given below.

<u>TEST POINT</u>	<u>Adjuster</u>
TP7	R69
TP8	R77
TP10	R88
TP11	R93

4.14 Frequency Counter

Specification: 10 - 9,999Hz within ± 1 count.

Connections : See Fig. 4-6.

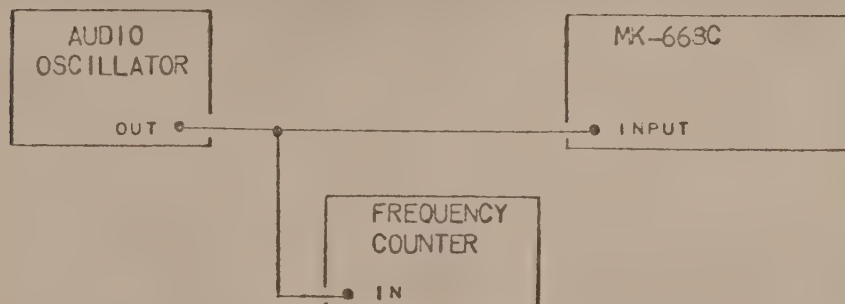


Fig. 4-6 Frequency counter checking.

1. Switch settings:

MODE at FREQUENCY COUNTER.

REFERENCE FREQUENCY at CRYSTAL.
(Rear panel)

- The counter should indicate within ± 1 count when the input frequency is varied from 10 to 9,999Hz.
- Set the REFERENCE FREQUENCY switch at 50Hz and 60Hz and the input frequency at 3,000Hz.

The counter indication should be as given below.

REF. FREQ. setting	Local line frequency	
	50Hz	60Hz
50Hz	3,000Hz	3,600Hz
60Hz	2,400Hz	3,000Hz

4.15 DC Power Supplies

NOTES: a. Refer to Fig. 4-7 for test points and adjusters.

b. The rated voltage is measured from the test point to chassis ground.

Rated Voltage	Tolerance	TEST POINT	Adjuster	PCB
+5V	$\pm 5\%$	Pin 8, IC1	None	P1-59
+200V	$\pm 10\%$	TP10	None	PCB-2
+15V	$\pm 1\%$	TP12	R23	
-15V	$\pm 1\%$	TP14	R32	

4.16 TROUBLESHOOTING

4.16.1 Power Section

- NOTES: a. Take care not to come into contact with the high AC and DC voltage terminals.
- b. The AC input should be at, or within $\pm 10\%$ of, the rated value specified on the title page of this manual.
- c. Allow at least 15 minutes for warm-up after the POWER switch has been turned on.

A. AC Input. (Refer to SCH 7 .)

Condition	Check for defect; replace if necessary
Pilot lamp does not light when POWER switch is at on	Line fuse; If it blows after replacement, check power transformer for shorted windings. Neon lamp, NE-101. AC cord and plug connections; VOLTAGE selector position (rear panel); Line filter, FIL-101.

B. DC Supplies (Refer to Fig. 4-7 and SCH 7 .)

TEST POINT	Output Voltage	If low, or no output	Check for defect; replace if necessary
TP10	+200V	Check voltage; TP10 to ground should be +200V $\pm 10\%$.	Rectifiers and filter circuit parts.
TP12	+15V	Check voltage; TP11 to ground should be +30V; adjust R23.	Rectifier CD4 and regulator parts.
TP14	-15V	Check voltage; TP13 to ground should be -30V; adjust R32.	Rectifier CD4 and regulator parts.
	+5V	At pin 8 of IC1, voltage to ground should be 5V $\pm 0.2V$.	On PCB P1-59: IC1 and parts in circuit.



4.16.2 Oscillator Output at 3kHz and 3.15kHz

NOTES: a. Refer to Fig. 4-7 and SCHEMATIC 5 for test points and adjusters

b. Connections:

AC millivoltmeter to OSC OUT terminals.

Calibrated oscilloscope at test points.

c. At each frequency, the output voltage should be $0.2V_{rms} \pm 20\%$. If not, adjust R16.

Condition	TEST POINT	Signal Amplitude	Check for defect; replace if necessary
Low, or no output- At 3kHz	TP2	3V 	TR2 and 3kHz bandpass filter circuit parts.
	TP1	4V 	Frequency dividers - IC5--IC9. 0.52MHz crystal oscillator circuit parts.
At 3.15kHz			Frequency dividers - IC13, IC14.

4.16.3 Frequency Counter Section (REFERENCE FREQUENCY at 50 or 60Hz -local)

- NOTES: a. Refer to Fig. 4-7 for test points and adjusters.
b. Proper signal amplitudes displayed on an oscilloscope at the test points are shown in the chart.

TEST PREPARATION:

1. Input signal: 10 - 9,999Hz at 1Vrms.
2. MODE switch at FREQUENCY COUNTER

Condition	TEST POINT	SCHEMATIC	Signal Amplitude	Check for defect; replace if necessary
INPUT MONITOR lamp does not light	(panel)	2		Lamp: 12V-20mA.
	TP3	1	4.8V 	Limiter: IC2, IC3.
	TP6	2	1.5VDC	Level monitor: TR13--TR16, Relay RLY-3, etc.
Counter display is faulty	TP6	5	11V 	TRIGGER I circuit parts, SCH 1 .
	TP5	5	3V 	If not indicated, go to TP4.
	TP4	5	3V 	TRIGGER II circuit parts: IC1--IC3, and IC10--IC12.
	TP7	5	4V 	IC15, IC16, IC19, IC18(1/4); C7, R6.
	TP9	5	4V 	If not indicated, go to TP8.
	TP8	5	4V 	IC17, IC18(1/4), C5, R4.

If the counter display is still not proper after the signal amplitude checks, then examine the following for defects:

On PCB:668B-7: 4-digit counter, IC1; switching transistors, Q1--Q8; resistors, R1-R17; diode, CD1; capacitor, C1.

On PCB:668B-8: IC1, V1--V4.

4.16.4 Wow Flutter Section

NOTES: a. Refer to Fig. 4-8 for test points and adjusters.

b. Proper signal amplitudes displayed on an oscilloscope at the test points are shown in the charts.

A. Input Circuit

Condition: INPUT MONITOR lamp does not light.

TEST PREPARATION:

1. Calibrator signal to INPUT terminals -

3kHz with 1% FM at 20Hz.

Input voltage at 5mV.

2. MK-668C settings -

MODE at W & F.

LEVEL at 5mV-30V.

TEST POINT	SCHEMATIC	Signal Amplitude	Check for defect; replace if necessary
TP2	1	8.5mV 	If not indicated, go to TP1.
TP1	1	13mV 	Input: TR1, TR2; R1--R6; C1. If good, check - 3kHz bandpass filter circuit parts.
TP3	1	4.7V 	Limiter: IC2, IC3; CD3--CD6; R17--R26; C7.
TP6	2	1.4VDC	Amplifier : TR13, TR14; R54--R61; C13--C16. If good, check - TR15, TR16; relay RLY-3, R63.

B. INDICATOR Section

Condition: WOW FLUTTER meter does not indicate properly.

TEST PREPARATION:

1. Calibrator signal to INPUT terminals -

3kHz with 1% FM at 20Hz.

Input voltage at 5mV.

2. MK-668C settings:-

MODE at W & F.

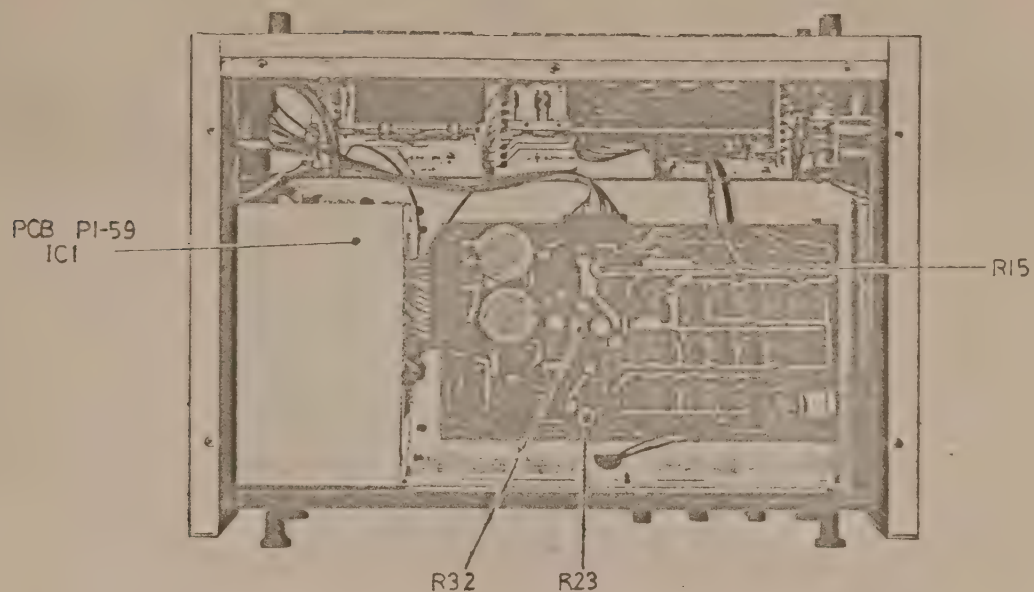
LEVEL at 5mV-30V.

INDICATION at JIS.

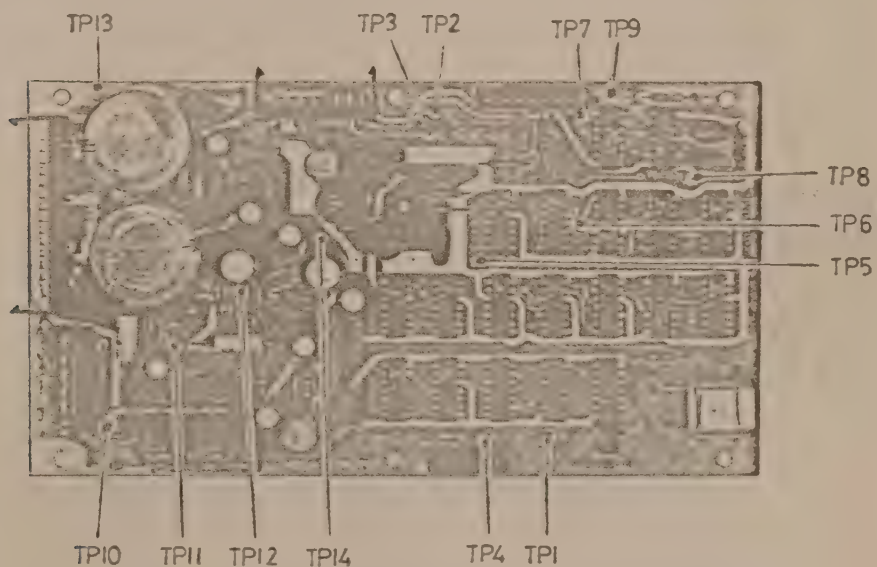
FUNCTION at UNWTD.

RANGE % at 1%.

TEST POINT	SCHEMATIC	Signal Amplitude	Check for defect; replace if necessary
TP4	1	4V 	TRIGGER I circuit; TR3--TR5; R27-R35; C8.
TP5	1	0.56V 	Discriminator; TR6--TR12; CD7--CD12; R36--R53; C10--C12.
TP7	3	2.8V 	AMPLIFIER I; IC4, R64--R70; C17--C19.
TP8	3	0.98V 	AMPLIFIER II; IC5; R71--R77; C21--C23; R1--R3 on PCB-3.
TP9	2	0.42V 	Impedance converter; IC6; R84. FUNCTION switch contacting.
TP10	4	0.85V 	AMPLIFIER III; IC7; R85--R89. R3, R4 on PCB-4, SCH. 3 INDICATION switch contacting.
TP11	4	9V 	AMPLIFIER IV; IC8; R90--R95; CD16--CD19; C25.
If the meter indication is still not proper after the signal amplitude checks, then examine the following for defects : Meter rectifier circuits. Meter for open circuit.			



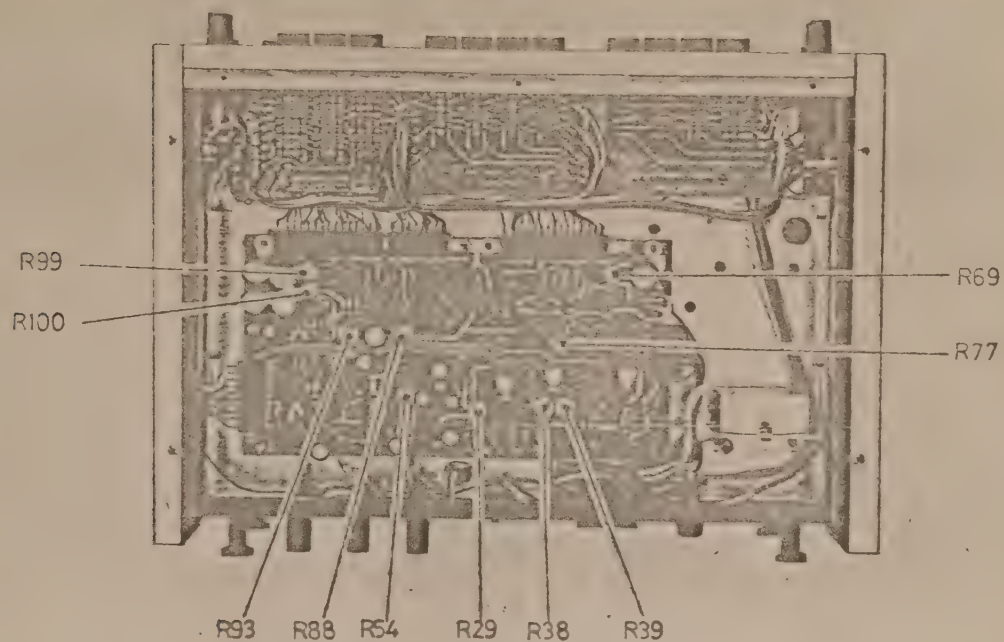
ADJUSTERS



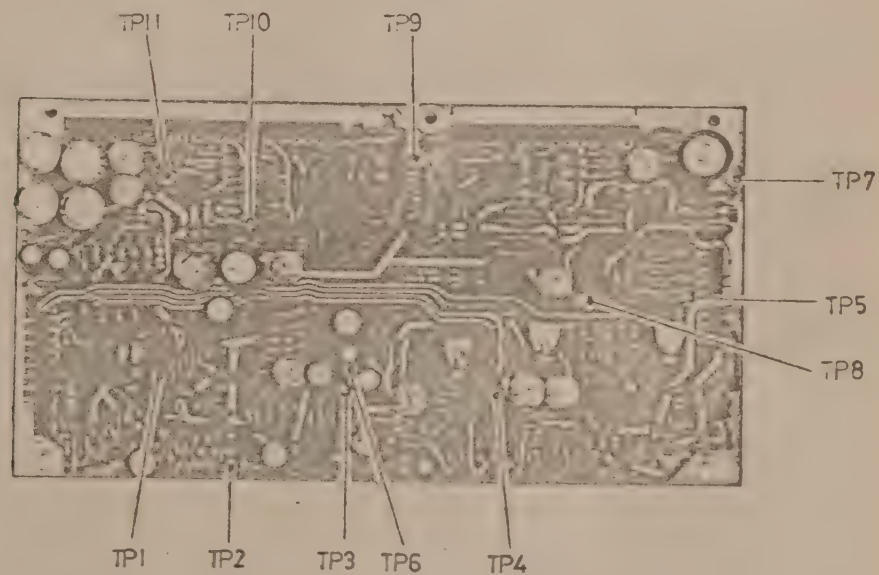
TEST POINTS

Note: PCB: P1 59 for +5V check of IC1 output is within the shield case used in older models. Late models do not have this case.

Fig. 4-7 Top views of PCB-2.



ADJUSTERS



TEST POINTS

Fig. 4-8 PCB-1 viewed from bottom side.

SCH 1

LIST OF ELECTRICAL COMPONENTS

PCB-1

Symbol	Description	Mfr. part No.	Note
R1	R: fxd, carbon f. 300 k Ω $\pm$ 5% 1/4 W	R1/4 300 k Ω J	
R2	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R3	R: fxd, carbon f. 13 k Ω $\pm$ 5% 1/4 W	R1/4 13 k Ω J	
R4	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R5	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R6	R: fxd, carbon f. 3.3 k Ω $\pm$ 5% 1/4 W	R1/4 3.3 k Ω J	
R7	R: fxd, carbon f. 51 k Ω $\pm$ 5% 1/4 W	R1/4 51 Ω J	
R8	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R9	R: fxd, carbon f. 47 k Ω $\pm$ 5% 1/4 W	R1/4 47 k Ω J	
R10	R: fxd, carbon f. 560 Ω $\pm$ 5% 1/4 W	R1/4 560 Ω J	
R11	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R12	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R13	R: fxd, carbon f. 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R14	R: fxd, carbon f. 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R15	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R16	R: fxd, carbon f. 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R17	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R18	R: fxd, carbon f. 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R19	R: fxd, carbon f. 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R20	R: fxd, carbon f. 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R21	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R22	R: fxd, carbon f. 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R23	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R24	R: fxd, carbon f. 130 k Ω $\pm$ 5% 1/4 W	R1/4 130 k Ω J	
R25	R: fxd, carbon f. 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R26	R: fxd, carbon f. 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R27	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R28	R: fxd, carbon f. 15 k Ω $\pm$ 5% 1/4 W	R1/4 15 k Ω J	
R29	R: Var, cermet 20 k Ω Lin 1/2 W	TM10K (PVB) 20 k Ω	
R30	R: fxd, carbon f. 5.6 k Ω $\pm$ 5% 1/4 W	R1/4 5.6 k Ω J	
R31	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R32	R: fxd, carbon f. 15 k Ω $\pm$ 5% 1/4 W	R1/4 15 k Ω J	
R33	R: fxd, carbon f. 3.3 k Ω $\pm$ 5% 1/4 W	R1/4 3.3 k Ω J	
R34	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	

SCH 1

PCB-1

Symbol	Description	Mfr. part No.	Note
R 35	R: fxd, carbon f. 2.2 k Ω $\pm$ 5 % 1/4 W	R1/4 2.2 k Ω J	
R 36	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R1/4 10 k Ω J	
R 37	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R1/4 10 k Ω J	
R 38	R: Var, cermet 50 k Ω Lin 1/2 W	TM10K (PVB) 50 k Ω	
R 39	R: Var, cermet 50 k Ω Lin 1/2 W	TM10K (PVB) 50 k Ω	
R 40	R: fxd, carbon f. 43 k Ω $\pm$ 5 % 1/4 W	R1/4 43 k Ω J	
R 41	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R1/4 10 k Ω J	
R 42	R: fxd, carbon f. 27 k Ω $\pm$ 5 % 1/4 W	R1/4 27 k Ω J	
R 43	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R1/4 10 k Ω J	
R 44	R: fxd, carbon f. 110 Ω $\pm$ 5 % 1/4 W	R1/4 110 Ω	
R 45	R: fxd, carbon f. 4.7 k Ω $\pm$ 5 % 1/4 W	R1/4 4.7 k Ω J	
R 46	R: fxd, carbon f. 3.3 k Ω $\pm$ 5 % 1/4 W	R1/4 3.3 k Ω J	
R 47	R: fxd, carbon f. 100 Ω $\pm$ 5 % 1/4 W	R1/4 100 Ω J	
R 48	R: fxd, carbon f. 5.1 k Ω $\pm$ 5 % 1/4 W	R1/4 5.1 k Ω J	
R 49	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R1/4 10 k Ω J	
R 50	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R1/4 10 k Ω J	
R 51	R: fxd, carbon f. 3.3 k Ω $\pm$ 5 % 1/4 W	R1/4 3.3 k Ω J	
R 52	R: fxd, carbon f. 12 k Ω $\pm$ 5 % 1/4 W	R1/4 12 k Ω J	
R 53	R: fxd, carbon f. 110 Ω $\pm$ 5 % 1/4 W	R1/4 110 Ω J	
CD 1	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 2	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 3	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 4	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 5	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 6	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 7	Diode: Si PIV 35 V 75 mA max	1 S 306	
CD 8	Diode: Si PIV 35 V 75 mA max	1 S 306	
CD 9	Diode: Si PIV 100 V 1 A max	F-14 A	
CD 10	Diode: breakdown 6.8 V 400 mW	RD-6.8 EB	
CD 11	Diode: breakdown 11 V 400 mW	RD-11 EB	
CD 12	Diode: Si PIV 100 V 1 A max	F-14 A	

SCH 1

PCB-1

Symbol	Description	Mfr. part No.	Note
C1	C: fxd, plastics 0.1 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 104 J	
C2	C: fxd, plastics 0.033 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 333 J	
C3	C: fxd, plastics 0.033 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 333 J	
C4	C: fxd, plastics 0.22 μ F $\pm$ 2% 100 WV	MM 82 A 224 G	
C4	C: fxd, plastics 0.033 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 333 J	
C5	C: fxd, AL elect, 10 μ F Bi-polar 25 WV	25 VBSN-10 B.P.	
C6	C: fxd, AL elect, 10 μ F Bi-polar 25 WV	25 VBSN-10 B.P.	
C7	C: fxd, AL elect, 10 μ F Bi-polar 25 WV	25 VBSN-10 B.P.	
C8	C: fxd, AL elect, 10 μ F Bi-polar 25 WV	25 VBSN-10 B.P.	
C9	C: fxd, dipped mica 220 pF $\pm$ 2% 300 WV	DM 10 YD 221 G 3	
C10	C: fxd, dipped mica 5600 pF $\pm$ 2% 300 WV	DM 19 YD 562 G 3	
C11	C: fxd, AL elect, 4.7 μ F 25 WV	25 VBSN-4.7	
C12	C: fxd, plastics 0.0047 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 472 J	
TR1	FET: Si Junction type	2 SK-30 A-Y	
TR2	Transistor: Si	2 SC-1345 F	
TR3	Transistor: Si	2 SC-372 G-0	
TR4	Transistor: Si	2 SC-372 G-0	
TR5	Transistor: Si	2 SC-372 G-0	
TR6	Transistor: Si	2 SC-1345 F	
TR7	Transistor: Si	2 SC-1345 F	
TR8	Transistor: Si	2 SC-1345 F	
TR9	Transistor: Si	2 SC-372 G-0	
TR10	Transistor: Si	2 SC-1345 F	
TR11	Transistor: Si	2 SC-1345 F	
TR12	Transistor: Si	2 SA-836 E	
IC1	Integrated Circuit: OP-AMP	LM 741 CN-8	
IC2	Integrated Circuit: OP-AMP	LM 741 CN-8	
IC3	Integrated Circuit: OP-AMP	LM 741 CN-8	
RLY 1	Relay: SPDT 12 V 37 mA	G 2 E DC-12 V 320 Ω	
RLY 2	Relay: SPDT 12 V 37 mA	G 2 E DC-12 V 320 Ω	

SCH 1

PCB-1

Symbol	Description	Mfr. part No.	Note
L 1	Inductor: W/shielded 100 mH $\pm 5\%$	FS 1215 S 1-104 J	
L 2	Inductor: W/shielded 100 mH $\pm 5\%$	MS-1116 S-104 J	
L 3	Inductor: W/shielded 15 mH $\pm 5\%$	MS-1012 S-153 J	

SCH 2

PCB-1

Symbol	Description	Mfr. part No.	Note
R 54	R: Var, cermet, 10 k Ω Lin 1/2 W	TM 10K (PVB) 10K	
R 55	R: fxd, carbon f. 47 k Ω $\pm 5\%$ 1/4 W	R 1/4 47 k Ω J	
R 56	R: fxd, carbon f. 3.3 k Ω $\pm 5\%$ 1/4 W	R 1/4 3.3 k Ω J	
R 57	R: fxd, carbon f. 4.3 k Ω $\pm 5\%$ 1/4 W	R 1/4 4.3 k Ω J	
R 58	R: fxd, carbon f. 620 Ω $\pm 5\%$ 1/4 W	R 1/4 620 Ω J	
R 59	R: fxd, carbon f. 1 k Ω $\pm 5\%$ 1/4 W	R 1/4 1 k Ω J	
R 60	R: fxd, carbon f. 2.2 k Ω $\pm 5\%$ 1/4 W	R 1/4 2.2 k Ω J	
R 61	R: fxd, carbon f. 33 k Ω $\pm 5\%$ 1/4 W	R 1/4 33 k Ω J	
R 62	R: fxd, carbon f. 5.1 k Ω $\pm 5\%$ 1/4 W	R 1/4 5.1 k Ω J	
R 63	R: fxd, carbon f. 110 Ω $\pm 5\%$ 1/4 W	R 1/4 110 Ω J	
*	R: fxd, carbon f. 110 Ω $\pm 5\%$ 1/4 W	R 1/4 110 Ω J	
CD 13	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 14	Diode: Si PIV 35 V 120 mA max	1 S 1588	
CD 15	Diode: Si PIV 100 V 1 A max	F-14 A	
C 13	C: fxd, AL elect 10 μ F Bi-polar 25 WV	25 VBSN-10 B.P.	
C 14	C: fxd, AL elect 10 μ F Bi-polar 25 WV	25 VBSN-10	
C 15	C: fxd, AL elect 47 μ F Bi-polar 25 WV	25 VBSN-47 B.P.	
C 16	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	
TR 13	Transistor: Si	2 SC 372 $\text{\textcircled{C}}$ -0	
TR 14	Transistor: Si	2 SC 372 $\text{\textcircled{C}}$ -0	
TR 15	Transistor: Si	2 SC 372 $\text{\textcircled{C}}$ -0	
TR 16	Transistor: Si	2 SC 372 $\text{\textcircled{C}}$ -0	
RLY-3	Relay: SPDT 12 V 37 mA	G 2 E DC-12 V 320 Ω	

SCH 3

PCB-1

Symbol	Description	Mfr. part No.	Note
R 64	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 65	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 66	R: fxd, carbon, 220 k Ω $\pm$ 5% 1/4 W	R1/4 220 k Ω J	
R 67	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 68	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 69	R: Var, cermet 10 k Ω Lin 1/2 W	TM10K (PVB) 10k Ω	
R 70	R: fxd, carbon, 30 Ω $\pm$ 5% 1/4 W	R1/4 30 Ω J	
R 71	R: fxd, carbon, 5.1 k Ω $\pm$ 5% 1/4 W	R1/4 5.1 k Ω J	
R 72	R: fxd, carbon, 7.5 k Ω $\pm$ 5% 1/4 W	R1/4 7.5 k Ω J	
R 73	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 74	R: fxd, carbon, 220 k Ω $\pm$ 5% 1/4 W	R1/4 220 k Ω J	
R 75	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 76	R: fxd, carbon, 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R 77	R: Var, cermet 10 k Ω Lin 1/2 W	TM10K (PVB) 10k Ω	
R 78	R: fxd, carbon, 68 k Ω $\pm$ 5% 1/4 W	R1/4 68 k Ω J	
R 79	R: fxd, carbon, 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R 80	R: fxd, carbon, 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R 81	R: fxd, carbon, 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R 82	R: fxd, carbon, 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R 83	R: fxd, carbon, 100 k Ω $\pm$ 5% 1/4 W	R1/4 100 k Ω J	
R 84	R: fxd, carbon, 1 M Ω $\pm$ 5% 1/4 W	R1/4 1 M Ω J	
C 17	C: fxd, plastics, 0.068 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 683 J	
C 18	C: fxd, plastics, 0.047 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 473 J	
C 19	C: fxd, dipped mica 1500 pF $\pm$ 2% 300 WV	DM 19 YD 152 G 3	
C 20	C: fxd, AL elect 220 μ F Bi-polar 25 WV	25 VBSN-220 [B.P.]	
C 21	C: fxd, plastics, 0.1 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 104 J	
C 22	C: fxd, plastics, 0.047 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 473 J	
C 23	C: fxd, dipped mica 1500 pF $\pm$ 2% 300 WV	DM 19 YD 152 G 3	
C 24	C: fxd, plastics, 0.47 μ F $\pm$ 2% 100 WV	MM 152 A 474 G	
C 25	C: fxd, plastics, 0.68 μ F $\pm$ 2% 100 WV	MM 152 A 684 G	
C 26	C: fxd, plastics, 0.33 μ F $\pm$ 2% 100 WV	MM 102 A 334 G	
C 27	C: fxd, plastics, 0.033 μ F $\pm$ 2% 100 WV	MM 82 A 333 G	
C 28	C: fxd, plastics, 0.27 μ F $\pm$ 2% 100 WV	MM 82 A 274 G	

SCH 3

PCB-1

Symbol	Description	Mfr. part No.	Note
C 29	C: fxd, plastics, 0. 27 μ F $\pm$ 2 % 100 WV	MM 82 A 274 G	
C 30	C: fxd, plastics, 0. 47 μ F $\pm$ 2 % 100 WV	MM 152 A 474 G	
C 31	C: fxd, plastics, 0. 33 μ F $\pm$ 2 % 100 WV	MM 102 A 334 G	
C 31	C: fxd, plastics, 0. 022 μ F $\pm$ 5 % 100 WV	CQ 92 MB 2 A 223 V	
C 32	C: fxd, plastics, 0. 68 μ F $\pm$ 2 % 100 WV	MM 152 A 684 G	
C 33	C: fxd, plastics, 0. 22 μ F $\pm$ 2 % 100 WV	MM 82 A 224 G	
C 33	C: fxd, plastics, 0. 033 μ F $\pm$ 5 % 100 WV	CQ 92 MB 2 A 333 J	
C 34	C: fxd, plastics, 0. 33 μ F $\pm$ 2 % 100 WV	MM 102 A 334 G	
IC 4	Integrated Circuit: OP-AMP	LM 741 CN-8	
IC 5	Integrated Circuit: OP-AMP	LM 741 CN-8	
IC 6	Integrated Circuit: OP-AMP	LM 741 CN-8	

SCH 3

PCB-3

Symbol	Description	Mfr. part No.	Note
R1	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R2	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R3	R: Var, cermet 500 Ω Lin 3/4 W	GFP-122 B 500 Ω	
R4	R: fxd, carbon f. 4.3 k Ω $\pm$ 5% 1/4 W	R1/4 4.3 k Ω J	
R5	R: fxd, carbon f. 4.3 k Ω $\pm$ 5% 1/4 W	R1/4 4.3 k Ω J	
R6	R: Var, cermet 2 k Ω Lin 3/4 W	GFP-122 B 2 k Ω	
R7	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R8	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R9	R: Var, cermet 5 k Ω Lin 3/4 W	GFP-122 B 5 k Ω	
R10	R: Var, cermet 1 M Ω Lin 3/4 W	GFP-122 B 1 M Ω	
R11	R: Var, cermet 1 M Ω Lin 3/4 W	GFP-122 B 1 M Ω	
R12	R: Var, cermet 1 M Ω Lin 3/4 W	GFP-122 B 1 M Ω	

SCH 3

PCB-4

Symbol	Description	Mfr. part No.	Note
R1	R: fxd, carbon f. 700 k Ω $\pm$ 2 % 1/4 W	R1/4 700 k Ω F	
R2	R: Var, cermet, 300 k Ω Lin 3/4 W	GFP-122 B 300 k Ω	
R3	R: fxd, carbon f. 700 k Ω $\pm$ 2 % 1/4 W	R1/4 700 k Ω F	
R4	R: Var, cermet, 300 k Ω Lin 3/4 W	GFP-122 B 300 k Ω	
R5	R: fxd, carbon f. 700 k Ω $\pm$ 2 % 1/4 W	R1/4 700 k Ω F	
R6	R: Var, cermet, 300 k Ω Lin 3/4 W	GFP-122 B 300 k Ω	
R7	R: Var, cermet, 100 k Ω Lin 3/4 W	GFP-122 B 100 k Ω	
C1	C: fxd, plastics, 0.22 μ F $\pm$ 2 % 100 WV	MM82 A 224 G	

SCH 4

PCB-1

Symbol	Description	Mfr. part No.	Note
R 85	R: fxd, carbon f. 10 M Ω $\pm$ 5 % 1/4 W	RD 1/4 PX 10 M Ω J	
R 86	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R 1/4 10 k Ω J	
R 87	R: fxd, carbon f. 91 k Ω $\pm$ 5 % 1/4 W	R 1/4 91 k Ω J	
R 88	R: Var, cermet 10 k Ω Lin 1/2 W	TM 10 K(PVB) 10 k Ω	
R 89	R: fxd, carbon f. 30 Ω $\pm$ 5 % 1/4 W	R 1/4 30 Ω J	
R 90	R: fxd, carbon f. 10 k Ω $\pm$ 5 % 1/4 W	R 1/4 10 k Ω J	
R 91	R: fxd, carbon f. 1 k Ω $\pm$ 5 % 1/4 W	R 1/4 1 k Ω J	
R 92	R: fxd, carbon f. 47 k Ω $\pm$ 5 % 1/4 W	R 1/4 47 k Ω J	
R 93	R: Var, cermet 10 k Ω Lin 1/2 W	TM 10 K(PVB) 10 k Ω	
R 94	R: fxd, carbon f. 22 k Ω $\pm$ 5 % 1/4 W	R 1/4 22 k Ω J	
R 95	R: fxd, carbon f. 11 k Ω $\pm$ 5 % 1/4 W	R 1/4 11 k Ω J	
R 96	R: fxd, carbon f. 30 k Ω $\pm$ 5 % 1/4 W	R 1/4 30 k Ω J	
R 97	R: fxd, carbon f. 12 k Ω $\pm$ 5 % 1/4 W	R 1/4 12 k Ω J	
R 98	R: fxd, carbon f. 20 k Ω $\pm$ 5 % 1/4 W	R 1/4 20 k Ω J	
R 99	R: Var, cermet 10 k Ω Lin 1/2 W	TM 10 K(PVB) 10 k Ω	
R 100	R: Var, cermet 100 k Ω Lin 1/2 W	TM 10 K(PVB) 100 k Ω	
C 35	C: fxd, AL elect 100 μ F Bi-pola 25 WV	25 VBSN-100 B.P.	
C 36	C: fxd, AL elect 47 μ F 25 WV	16 VBSN-47	
C 37	C: fxd, AL elect 47 μ F 25 WV	16 VBSN-47	
C 38	C: fxd, AL elect 33 μ F 50 WV	KU 50 VB 33	
C 39	C: fxd, AL elect 33 μ F 50 WV	KU 50 VB 33	
C 40	C: fxd, AL elect 33 μ F 50 WV	KU 50 VB 33	
C 41	C: fxd, AL elect 33 μ F 50 WV	KU 50 VB 33	
CD 16	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 17	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 18	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 19	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 20	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 21	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 22	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 23	Diode: Ge PIV 75 V 30 mA max	SD 34	

SCH 4

PCB-1

Symbol	Description	Mfr. part No.	Note
CD 24	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 25	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 26	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 27	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 28	Diode: Ge PIV 75 V 30 mA max	SD 34	
CD 29	Diode: Ge PIV 75 V 30 mA max	SD 34	
IC 7	Integrated Circuit: OP-AMP	LM 741 CN-8	
IC 8	Integrated Circuit: OP-AMP	LM 741 CN-8	

SCH 5

PCB-2

Symbol	Description	Mfr. part No.	Note
R1	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R2	R: fxd, carbon f. 680 Ω $\pm$ 5% 1/4 W	R1/4 680 Ω J	
R3	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R4	R: fxd, carbon f. 430 Ω $\pm$ 5% 1/4 W	R1/4 430 Ω J	
R5	R: fxd, carbon f. 430 Ω $\pm$ 5% 1/4 W	R1/4 430 Ω J	
R6	R: fxd, carbon f. 430 Ω $\pm$ 5% 1/4 W	R1/4 430 Ω J	
R7	R: fxd, carbon f. 3.3 k Ω $\pm$ 5% 1/4 W	R1/4 3.3 k Ω J	
R8	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R9	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R10	R: fxd, carbon f. 1 k Ω $\pm$ 5% 1/4 W	R1/4 1 k Ω J	
R11	R: fxd, carbon f. 4.7 k Ω $\pm$ 5% 1/4 W	R1/4 4.7 k Ω J	
R12	R: fxd, carbon f. 470 Ω $\pm$ 5% 1/4 W	R1/4 470 Ω J	
R13	R: fxd, carbon f. 110 Ω $\pm$ 5% 1/4 W	R1/4 110 Ω J	
R14	R: fxd, carbon f. 62 Ω $\pm$ 5% 1/4 W	R1/4 62 Ω J	
R15	R: Var, cermet 1 k Ω Lin 1/2 W	TM10K(PVB) 1k Ω	
R16	R: fxd, carbon f. 110 Ω $\pm$ 5% 1/4 W	R1/4 110 Ω J	
CD1	Diode: Si PIV 35 V 120 mA max	1 S1588	
C1	C: fxd, dipped mica 100 pF $\pm$ 2% 300 WV	DM05 YD101 G3	
C2	C: fxd, dipped mica 100 pF $\pm$ 2% 300 WV	DM05 YD101 G3	
C3	C: fxd, plastics, 0.022 μ F $\pm$ 5% 100 WV	CQ92 MB2 A223 J	
C4	C: fxd, dipped mica 100 pF $\pm$ 2% 300 WV	DM05 YD101 G3	
C5	C: fxd, plastics, 0.1 μ F $\pm$ 5% 100 WV	CQ92 MB2 A104 J	
C6	C: fxd, plastics, 0.1 μ F $\pm$ 5% 100 WV	CQ92 MB2 A104 J	
C7	C: fxd, plastics, 0.1 μ F $\pm$ 5% 100 WV	CQ92 MB2 A104 J	
C8	C: fxd, AL elect 1 μ F 50 WV	50 VBSN-1	
C9	C: fxd, plastics, 0.033 μ F $\pm$ 5% 100 WV	CQ92 MB2 A333 J	
C10	C: fxd, plastics, 0.033 μ F $\pm$ 5% 100 WV	CQ92 MB2 A333 J	
C11	C: fxd, plastics, 0.22 μ F $\pm$ 2% 100 WV	MM82 A224 G	
*	C: fxd, AL elect 10 μ F 16 WV	16 VBSN-10	
L1	Inductor: W/shielded 100 mH $\pm$ 5%	FS1215 S1-104 J	
L2	Inductor: W/shielded 100 mH $\pm$ 5%	FS1215 S1-104 J	
L3	Inductor: W/shielded 15 mH $\pm$ 5%	FS1215 S1-153 J	

SCH 5

PCB-2

Symbol	Description	Mfr. part No.	Note
IC 1	Integrated circuit: SCHMITT TRIGGER	SN 7413 N	
IC 2	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 3	Integrated circuit: TWELVE COUNTER	SN 7492 AN	
IC 4	Integrated circuit: QUAD 2 NAND	SN 7400	
IC 5	Integrated circuit: BINALY COUNTER	SN 7493 N	
IC 6	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 7	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 8	Integrated circuit: QUAD 2 NAND	SN 7400	
IC 9	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 10	Integrated circuit: TWELVE COUNTER	SN 7492 AN	
IC 11	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 12	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 13	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 14	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 15	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 16	Integrated circuit: DECADE COUNTER	SN 7490 AN	
IC 17	Integrated circuit: QUAD 2 NAND	SN 7400	
IC 18	Integrated circuit: QUAD 2 NAND	SN 7400	
IC 19	Integrated circuit: QUAD 2 NAND	SN 7400	
XT 1	Crystal unit: 2.52 MHz	2.52 MHz	

SCH 6

668 B-7, 668 B-8

Symbol	Description	Mfr. part No.	Note
R1	R: fxd, carbon f. 33 k Ω $\pm$ 5% 1/4 W	R1/4 33 k Ω J	
R2	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R3	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R4	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R5	R: fxd, carbon f. 2.2 k Ω $\pm$ 5% 1/4 W	R1/4 2.2 k Ω J	
R6	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R7	R: fxd, carbon f. 47 k Ω $\pm$ 5% 1/4 W	R1/4 47 k Ω J	
R8	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R9	R: fxd, carbon f. 47 k Ω $\pm$ 5% 1/4 W	R1/4 47 k Ω J	
R10	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R11	R: fxd, carbon f. 47 k Ω $\pm$ 5% 1/4 W	R1/4 47 k Ω J	
R12	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R13	R: fxd, carbon f. 47 k Ω $\pm$ 5% 1/4 W	R1/4 47 k Ω J	
R14	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R15	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R16	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
R17	R: fxd, carbon f. 10 k Ω $\pm$ 5% 1/4 W	R1/4 10 k Ω J	
CD1	Diode: Si PIV 35 V 120 mA max	1 S 1588	
C1	C: fxd, plastics, 0.022 μ F $\pm$ 5% 100 WV	CQ 92 MB 2 A 223 J	
Q1	Transistor Si	2 SC780 A $\text{\textcircled{C}}$	
Q2	Transistor Si	2 SA 429 $\text{\textcircled{C}}$	
Q3	Transistor Si	2 SC780 A $\text{\textcircled{C}}$	
Q4	Transistor Si	2 SA 429 $\text{\textcircled{C}}$	
Q5	Transistor Si	2 SC780 A $\text{\textcircled{C}}$	
Q6	Transistor Si	2 SA 429 $\text{\textcircled{C}}$	
Q7	Transistor Si	2 SC780 A $\text{\textcircled{C}}$	
Q8	Transistor Si	2 SA 429 $\text{\textcircled{C}}$	
IC1	Integrated circuit: 4-Digit Decade Counter	TC 5001 C	
IC2	Integrated circuit: BCD/DEC DECORDER	SN 74141 N	

SCH 6

668 B-7, 668 B-8

Symbol	Description	Mfr. part No.	Note
V 1	Tube : Display tube 0 — 9	CD 66 A	
V 2	Tube : Display tube 0 — 9	CD 66 A	
V 3	Tube : Display tube 0 — 9	CD 66 A	
V 4	Tube : Display tube 0 — 9	CD 66 A	



SCH 7

PCB-2

Symbol	Description	Mfr. part No.	Note
R16	R: fxd, carbon f. 130 k Ω $\pm$ 5 % 1/4 W	R1/4 130 k Ω J	
R17	R: fxd, carbon f. 3.3 k Ω $\pm$ 5 % 1/4 W	R1/4 3.3 k Ω J	
R18	R: fxd, carbon f. 100 k Ω $\pm$ 5 % 1/4 W	R1/4 100 k Ω J	
R19	R: fxd, WW 1 Ω $\pm$ 5 % 2 W	MS-2 1 Ω J	
R20	R: fxd, carbon f. 15 k Ω $\pm$ 5 % 1/4 W	R1/4 15 k Ω J	
R21	R: fxd, carbon f. 910 Ω $\pm$ 5 % 1/4 W	R1/4 910 Ω J	
R22	R: fxd, carbon f. 6.8 k Ω $\pm$ 5 % 1/4 W	R1/4 6.8 k Ω J	
R23	R: Var, cermet 5 k Ω Lin 1/2 W	TM10K(PVB) 5k Ω	
R24	R: fxd, carbon f. 3.3 k Ω $\pm$ 5 % 1/4 W	R1/4 3.3 k Ω J	
R25	R: fxd, carbon f. 1.6 k Ω $\pm$ 5 % 1/4 W	R1/4 1.6 k Ω J	
R26	R: fxd, WW 1 Ω $\pm$ 5 % 2 W	MS-2 1 Ω J	
R27	R: fxd, carbon f. 1.6 k Ω $\pm$ 5 % 1/4 W	R1/4 1.6 k Ω J	
R28	R: fxd, WW 1 Ω $\pm$ 5 % 2 W	MS-2 1 Ω J	
R29	R: fxd, carbon f. 15 k Ω $\pm$ 5 % 1/4 W	R1/4 15 k Ω J	
R30	R: fxd, carbon f. 910 Ω $\pm$ 5 % 1/4 W	R1/4 910 Ω J	
R31	R: fxd, carbon f. 3.3 k Ω $\pm$ 5 % 1/4 W	R1/4 3.3 k Ω J	
R32	R: Var, cermet 5 k Ω Lin 1/2 W	TM10K(PVB) 5k Ω	
R33	R: fxd, carbon f. 6.8 k Ω $\pm$ 5 % 1/4 W	R1/4 6.8 k Ω J	
CD2	Diode: Si PIV 400 V 1 A	F14 D	
CD3	Diode: Si PIV 400 V 1 A	F14 D	
CD4	Rectifier: Si Bridge type, 200 V 1 A	KBP-02	
CD5	Diode: breakdown 6.2 V 400 mW	RD6.2 EB	
CD6	Diode: breakdown 6.2 V 400 mW	1 N 823	
CD7	Diode: breakdown 6.2 V 400 mW	RD6.2 EB	
CD8	Diode: breakdown 6.2 V 400 mW	1 N 823	
C12	C: fxd, AL elect 10 μ F 350 WV	350 TA-10	
C13	C: fxd, AL elect 10 μ F 350 WV	350 TA-10	
C14	C: fxd, AL elect 10 μ F 350 WV	350 TA-10	
C15	C: fxd, AL elect 2200 μ F 50 WV	ECE-T 50 R 2200 S	
C16	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	
C17	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	
C18	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	

SCH 7

PCB-2

Symbol	Description	Mfr. part No.	Note
C19	C: fxd, AL elect 470 μ F 16 WV	16 VBSN-470	
C20	C: fxd, AL elect 2200 μ F 50 WV	FCE-T 50 R 2200 S	
C21	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	
C22	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	
C23	C: fxd, AL elect 47 μ F 25 WV	25 VBSN-47	
C24	C: fxd, AL elect 470 μ F 16 WV	16 VBSN-470	
TR3	Transistor: Si	2 SC944	
TR4	Transistor: Si	2 SC944	
TR5	Transistor: Si	2 SA836 $\text{\textcircled{E}}$	
TR6	Transistor: Si	2 SA836 $\text{\textcircled{E}}$	
IC20	Integrated circuit: OP-AMP	LM-741	
IC21	Integrated circuit: OP-AMP	LM-741	

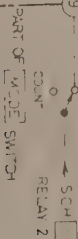
ACB-1



INPUT CIRCUITS

SELECTED

PCM-1



12, 20mA

Unless otherwise indicated

Unless otherwise indicated

Unless otherwise indicated:

Resistors 12 watt

Resistors 1 Zwart!

☒ NAME Screwdriver adjustment in case

NAME _____

Screwdriver adjustment in case _____

Screwdriver adjustment on driver _____

NAME Knob control and Panel markings

NAME: Knob control and Panel markings

Typical voltage shown m10k Q/V test or VTVM.
Rotary switch shown in max CCW position.

Rotary switch section shown in max CW position

[PCB] Printed Circuit Board

Connector or Terminal number

Connector or Terminal Number

CHANGES

CHANGES:

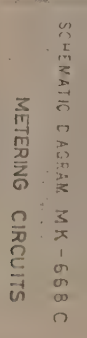
DRAWING: SHIONO

DATE: 1976.2

DATE: 1976.2

SCHEMATIC DIAGRAM MK-658C

INPUT LEVEL MONITOR





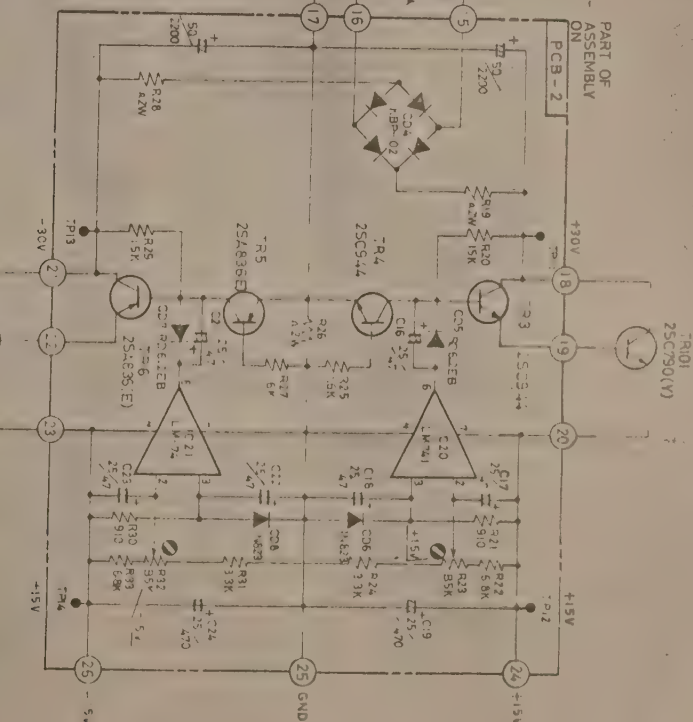
- NOTES
- Press ϕ screw, use indicated
Resistance in Ω K Ω M Ω
Resistors 1 2 watt
Capacitors in μF μF
NAME Screwdriver adjustment in case
NAME Screwdriver adjustment on panel
NAME Knob control and Panel markings

Typical voltage shown in ICh 2/V tester or VTVM
Rc1a1 5w 1ch section shown in max CCW position
a. Value selected at factory. Average value shown
Pc1a Printed Circuit Board
3. 0 Connector or Terminal number

CHANGES
DRAWING: S.H. ONO
CHECK:
DATE: 1976.2

SCHEMATIC DIAGRAM MK - 668 C

FREQUENCY COUNTER DISPLAY CIRCUITS

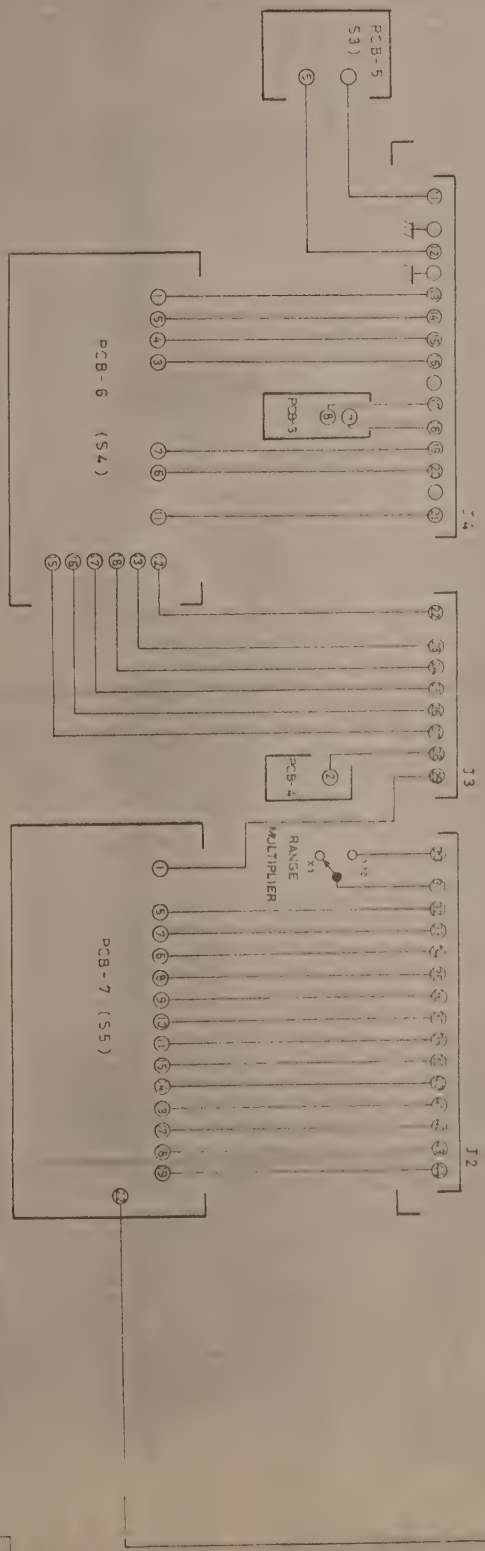
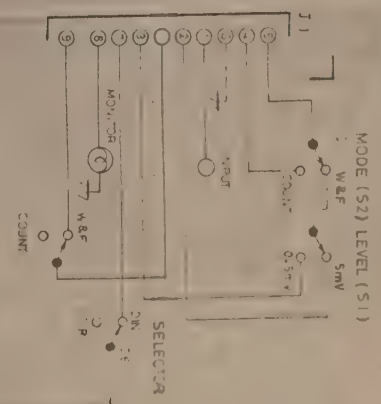
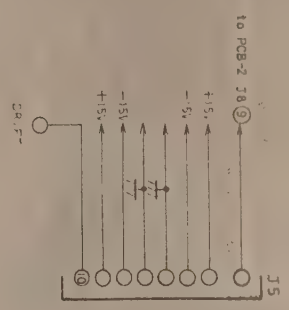


7

MK - 668 C PCB-1

CONNECTORS:

- J1 : SCH-11
- J2 : SCH-12
- J3 : SCH-13
- J4 : SCH-14
- J5 : SCH-15



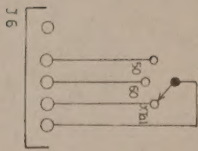
NOTES:
 Unless otherwise indicated:
 Resistance in Ω , k, M, M-M, M-M
 Capacitance in pF, μ F, nF
 1. NAME: Schematic adjustment on case
 2. NAME: Schematic adjustment on case
 3. NAME: Schematic adjustment on case
 4. NAME: Schematic adjustment on case

Typical voltage shown in Ω , k, M, M-M, M-M
 Rotary switch section shown in max CCW position
 1. Value selected at factory. Average value shown
 2. Printed Circuit Board
 3. Connector or Terminal number

CHANGES:
 DRAWING SHONO
 CHECK:
 DATE 1976. 2

SCHEMATIC DIAGRAM MK-668 C
 CONNECTORS ON PCB-1

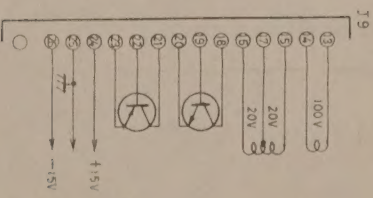
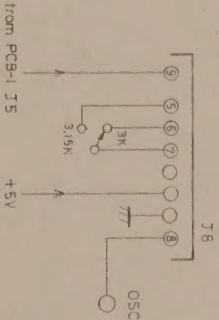
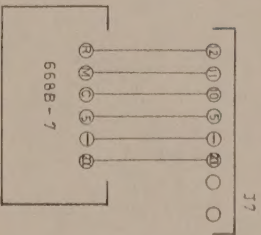
REF. FREQ.



MK-668 C PCB-2

CONNECTORS:

- J6 : SCH-5
- J7 : *
- J8 : *
- J9 : SCH-7



NOTES:
 1. Resistance indicated
 2. Resistance in Ohms
 3. Resistance in Kilo Ohms
 4. Resistance in Mega Ohms
 5. Capacitance in pF
 6. NAME: Screwdriver adjustment in case
 7. NAME: Screwdriver adjustment in case
 8. NAME: Knob control and Panel markings

Typical voltage shown in Ohm/V test or VTVM
 Rotary switch section shown in max CCM position
 * Value selected at factory. Average value shown
 PCB: Printed Circuit Board
 2: Connector or Terminal number

CHANGES
 DRAWING SHONO
 CHECK
 DATE 1976.2

SCHEMATIC DIAGRAM MK-668 C
 CONNECTORS ON PCB-2

